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THE TWO LARGEST VESSELS yet designed for the ore trade on the Lakes have just been contracted for by the Bessemer Steamship Co. The first is a steamer, to be built by the Globe Iron Works Co., of Cleveland, O., 475 ft. long, and 50 ft. beam, with quadruple expansion engines. The second is a barge, 460 ft. long, 50 ft. wide and 30 ft. deep, to carry 7,500 tons on 17½ ft. draft, to be built by the American Steel Barge Co., Superior, Wis.

THE LARGEST ORDER FOR WATER-TUBE BOILERS ever given in this country, so far as we are aware, is that which the Cramp Co., Philadelphia, has just given to the Stirling Co., of Chicago, for the water-tube marine boilers for Russian war vessels, now under construction at the Cramp yards, amounting to about 35,000 HP.

THE REDUCTION IN THE COST of producing iron and steel in the United States, since 1880, is commented upon by the English "Iron and Coal Trade Review." According to that journal, the labor cost of producing crucible steel, in 1860-'65, was about $75 per ton, and is now not over $2.40. Between 1880 and 1890, the labor cost of producing a ton of pig-iron was more than twice what it is now, broadly speaking. The raw material also costs less. Lake Superior ores, at Pittsburg, have fallen from $8.40 to $3.60 per ton in comparatively recent times, and coke, at Chicago, has fallen from $7.20 to $2.88 and $3.60 per ton. The wages cost of producing a ton of pig iron, at Pittsburg, less than 25 years ago, was fully $4.80; to-day it costs from 48 to 72 cts. in the best managed works. Twenty years ago mine owners wanted $2.40 a ton profit on ore, for the highest grades; to-day they will accept less than 24 cts; and the same decrease in profits demanded applies to the pig iron maker, the coke manufacturer and the producer of finished products. The writer says that the success of the American iron and steel producers is due to their vigorous and persistent attention to business administration, in mining, manufacture and transportation.

STANDARD STEEL BRIDGE PLANS FOR CHINA are being made by C. F. Loweth, M. Am. Soc. C. E., Chief Engineer of the Davenport & Rock Island Bridge, Railway & Terminal Co., of Davenport, Ia. The structures range from small plate girders to 200-ft. spans. They are being made for the Chinese Railway Administration.

NEW YORK'S OCEAN TONNAGE, says the N. Y. "Journal of Commerce," is only exceeded by that of London. For the fiscal year 1898, the aggregate tonnage of vessels entering and declaring at New York was 15,337,142 tons; this is only approached by the year 1880, with a tonnage of 15,041,083 tons. The condition of the carrying trade, for 1898, is shown as follows, for entering vessels: 449 American sailing vessels, 231 686 tons; 282 American steamships, 720,553 tons; 787 foreign sailing vessels, 531,295 tons; 2,817 foreign steamships, 6,277,878 tons; total, entering, 4,335 vessels, carrying 7,761,412 tons. The vessels clearing from New York in the year numbered 4,727, in about the same proportions as above, and they carried 7,575,730 tons. As compared with English ports, for 1897, we find a total inward and outward movement of 15,797,659 tons for London, and 11,261,051 tons for Liverpool. In 1883 and 1892, however, New York surpassed London in the aggregate of tonnage.

A TORPEDO-BOAT SPEED COURSE, one measured mile in length, has been located by the Navy Department on the Delaware River, below the mouth of Christiana Creek. All torpedo boats hereafter built on the Atlantic coast will be tested for speed over this measured mile; the course allows one mile more in which to get up speed and another mile in which to slow down.

THE SPANISH CRUISER "REINA MERCEDES" was sunk in Santiago Bay by the Spaniards by opening the sea-valves, reports Lieut. Lucian Young, U. S. N. Her hull is otherwise in good condition, and is resting on the edge of the channel bank, with 110 ft. overhanging deep water. Lieut. Young thinks that by plugging the valves she could be pumped out and raised. The latest accounts indicate the final abandonment of the Spanish cruiser "Maria Teresa," raised at Santiago and wrecked on Cat Island on her way to Norfolk.

THREE OF THE SPANISH SHIPS SUNK AT MANILA are to be raised by a Hong Kong firm of wreckers and put in thorough repair for $500,000, according to a contract just made by Admiral Dewey. These ships are large gunboats; two, the "Isla de Cuba" and the "Isla de Luzon," are 200 ft. long, 30 ft. beam and 11½ ft. draft, with a displacement of 1,040 tons each. They are built of steel, have twin screws, a good protective deck and a battery of six 4.7-in. Hontoria guns, four 6-pdrs, two 1-pdrs., two Nordenfeldt guns and three torpedo tubes. The speed is 15.8 knots under forced draft. The other, the "Don Juan de Austria," is 210 ft. long, 32 ft. beam, 12½ ft. draft and 1,152 tons displacement. She was built at Carthagena in 1887, and her armament includes four 4.7-in. Hontoria guns, four 6-pdrs., one machine gun and two torpedo tubes. These vessels are to be raised under the superintendence of Naval Constructor W. L. Capps, U. S. N.

THE BUFFALO RIVER IMPROVEMENT, in Buffalo, N. Y., has reached the stage of completion of plans and specifications, which are now to be submitted to the Board of Public Works with a request for the issue of proposals. This work contemplates the widening, straightening and deepening of Buffalo River, between Hamburg St. and the east city line, and also of Cazenovia Creek, from its junction with the river to Cazenovia St. The plan for the river proposes a bottom width of 230 ft. to the creek, 150 ft. beyond the creek, and 120 ft. in Cazenovia Creek. The sides are to be diked 15 ft. above the normal water surface, and the estimated quantity of material to be moved is 3,000,000 cu. yds. The estimated cost of dredging is about $700,000. Five highway and six railway bridges, crossing these streams, will have to be altered. Bids may be advertised for shortly, though there may be some opposition from the railway companies affected.

THE SEA-WALL AT CHICAGO, which was built to protect the Lake Shore drive, has been broken away by the waves of the recent severe storms on Lake Michigan, and a gap of about 80 ft. in width has been formed. The wall is of concrete, with a foundation of piling. There are two rows of piles, those of the front row being set close together, and those of the back row 4 ft. apart. The space between them was filled with bundles of brush, covered with rubble stone. A decking of several layers of plank on top of the piles forms the base for the concrete wall. The spaces between the piles in the front row were wide enough to allow of a steady wash of the water, disturbing the ground and allowing the brush and stone to settle and wash out. The horizontal and vertical action of the waves of a high sea soon breached the foundation and overturned the wall. This result appears to be due to the fact that the work, like other public works in Chicago, was not properly executed. The design originally prepared by Gen. Fitz Simons included a revetment at the toe of the wall, and a line of sheet piling in front of the revetment, thus preventing any wave action from reaching the foundations. The stone filled crib work of the bulkhead wall for the future Lake Front Park received little if any damage during the storms.

DEFECTIVE SEWER WORK on the intercepting sewers in Chicago has been charged by a local paper, the principal charge being that some of the brick rings, especially in the invert, are laid without cement, and also that the work is done without properly draining or pumping out the trench, so that the invert is built in mud and water. The charges were insisted upon so strenuously, that Mr. McGann, Commissioner of Public Works, consented to have an inspection made by an engineer appointed by this newspapers. Gen. Sooy Smith, M. Am. Soc. C. E., accepted the appointment, and had openings cut in the walls of the North Side sewer. His report states that the materials and workmanship are good, except that at one or two points the middle ring of brick was laid without mortar or with a less quantity than the outer rings. He further stated that this lack of mortar in the middle ring "was a defect such as sometimes creeps into brickwork in sewer linings in spite of the best intentions and instructions of the contractors, and the vigilance of the inspectors in charge of the work." The newspaper which made the charges, however, now complains that the invert was not examined, that the inspection was not made at the points where it had reported bad work, and that none of its representatives were with the inspecting party.

The MOST SERIOUS RAILWAY ACCIDENT of the week occurred Nov. 18, on the Pennsylvania R. R., just east of the Hackensack River, near Jersey City, N. J., and caused the deaths of 11 track laborers, and the injury of as many more. The gang was at work on the west-bound track and moved over to the east-bound track to let a train pass. The noise of the passing train prevented their hearing an approaching east-bound express, and the dense fog, which prevailed at the time, hid it from their sight.

TWO FATAL ACCIDENTS, due to low hanging arc lights, recently occurred in Baltimore, Md., and have served to arouse the question of responsibility and whether the Police Board had authority to compel electric light companies to place arc lights at a safe distance above pavements. Mr. G. R. Gaither, Counsel to the Board, states that:

> It is clear that whenever such lights are so placed as to endanger the lives of the persons who use the streets, such lights become a nuisance and should be removed, or the parties causing the nuisance punished. Anything which endangers the safety of persons lawfully passing over a highway is an obstruction and indictable as such.
> I am of the opinion that your honorable board should instruct the members of the force to notify any company having arc lights in a position which is dangerous to the public safety to remove them to a proper and safe position, and in the event of the failure of any company to do so, to lay the matter before the state's attorney with the evidence, so that an indictment may be found by the grand jury against the offending parties.

A CONTRACT FOR 15,000 ELECTRICAL HORSE-power was closed on Nov. 21 between the Union Carbide Co. and the Niagara Falls Power Co., the power to be delivered some time next summer. This great block of power is the product of three of the big dynamos in the great Niagara central station. The existing works of the Carbide Co. will be continued, but in order to utilize the additional amount of power, immense new works will be constructed at once. The buildings will be located on the power company's lands near the trestle of the Niagara Junction Ry. and north of the Erie and Central tracks. One of the buildings will be two stories high and over 800 ft. long.

PAYMENT FOR ALLEGED DAMAGE by electrolysis has been made by the Consolidated Street Railway Co. to the city of Atlanta, Ga. The amount was small, only $16.91, and was paid under protest in settlement of two bills presented by the city for damages to its water mains or services. The council passed an ordinance, not long ago, requiring all electrical companies in Atlanta to keep their currents off water and other pipes.

IN REGARD TO INDUSTRIAL ENTERPRISES IN Cuba, Special Commissioner Robert P. Porter, reports to the President that little can be done until the sanitary conditions can be improved in all the industrial centers. For the commercial prosperity of Cuba, and for that of the Southern part of the United States as well, the germs of yellow fever, existing in all the larger Cuban towns, must be destroyed. Mr. Porter recommends the appointment of a commission of experts, including engineers of skill and experience, which shall make a sanitary survey of Havana and Matanzas, and report what can be done to stamp out yellow fever in these cities.

PROGRESS ON THE TRANS-SIBERIAN RAILWAY is reported as follows by the London "Times": By the Russian-Chinese treaty of September, 1896, a large part of the old line to Vladivostock, by way of the Amour River, was abandoned, and a new line laid down from Stretensk across Eastern China, or Manchuria, directly to Vladivostock. But, as a consequence of the establishment of the Russians on the Gulf of Pe-chi-li, the terminus is now Port Arthur, and the latest route leaves the old line at Chi-Tai, about 300 miles from Lake Baikal and far west of Stretensk. The rails are now laid to Listvenitchoie, on the west bank of Lake Baikal; the large ice-breaking ferryboat, for taking trains across the lake to Masova, is under construction, and in the coming spring, the line around the lake will be commenced. East of Lake Baikal the rails are being laid at the rate of four miles per day. Train service with Europe commences at Irkoutsk; from this point west to Krasnoiarsk the line is being operated, but is not finished, and the Oka and Ienissei rivers are crossed in boats. West of Krasnoiarsk the line is in complete working order. The trip from Moscow to Lake Baikal, second-class, costs about $24 and occupies about 12 days; first-class carriages only go once a week as far as Tomsk, and ordinary trains go once a day to Krasnoiarsk, and three times a week to Irkoutsk. All cars, however, are provided with reclining chairs, for sleeping purposes.

TRIPLE-EXPANSION PUMPING ENGINE AT OGDENSBURG, N. Y.

By Charles A. Hague, M. Am. Soc. M. E.*

(With two-page plate.)

This engine, just installed by the Snow Steam Pump Works, of Buffalo, N. Y., in the pumping station of the Ogdensburg City water-works, represents the most advanced practice in the type technically known as low-duty triple expansion. The engine is of the horizontal condensing duplex

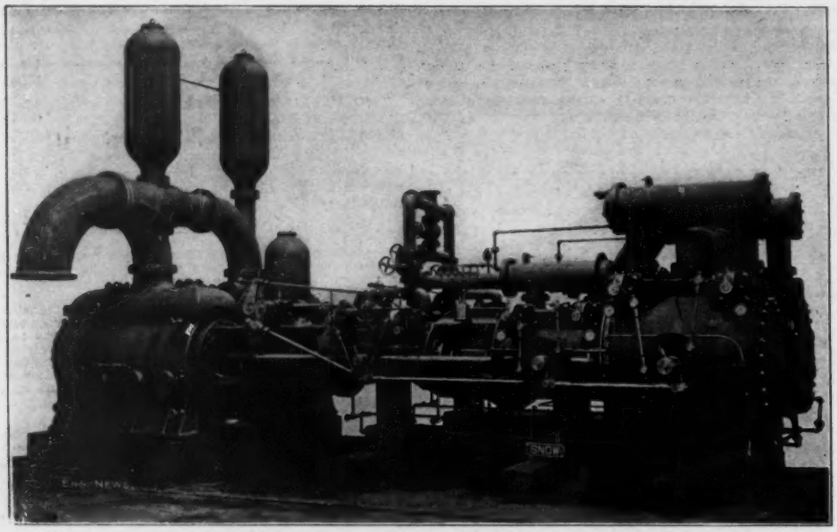

FIG. 1.—VIEW OF TRIPLE EXPANSION PUMPING ENGINE AT OGDENSBURG, N. Y.
The Snow Steam Pump Works, Buffalo, N. Y.

direct-acting class, with a high, an intermediate, and a low pressure cylinder on each side of the machine, each set of cylinders operating a double-acting plunger contained within separate water cylinders; the water cylinders being connected to common suction and delivery pipes by means of cross pipes, in the usual manner.

Each high pressure cylinder has a diameter of 16 ins., intermediate, 23 ins., and low pressure, 40 ins. The pump plungers each have a diameter of 23¼ ins., the common stroke of all being 36 ins. The steam distributing valves are of the semi-rotative, or "Corliss" type, and are arranged as follows: At each end of the high pressure cylinder is a valve for the double purpose of admission and exhaust, while directly above each of these valves is placed an independent cut-off valve, thus reducing the clearance to a low percentage, and as the low piston speed permits of considerable restriction in the port area, the valves are made

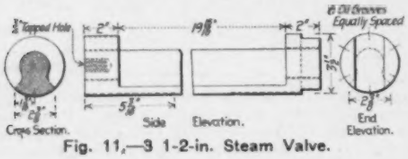

Fig. 11.—3 1-2-in. Steam Valve.

comparatively short, thereby eliminating to a great extent the corners formed by the spaces usually found in this form of steam valve, having ports of a length equal or nearly equal to the diameter of the cylinder, such as would, of course, be necessary at high piston speeds. At each end of the intermediate and low pressure cylinders are similar valves, with the exception of the cut-off valves, which are omitted on the latter two cylinders.

The point of cut-off in the high-pressure cylinder is determined by the ability of the engine to finish its stroke at the various speeds at which it may be running, the higher the speed the shorter the cut-off, and although in any event no very short cut-off can be obtained, still it is sufficiently early to produce an economy which well repays the addition of the two high-pressure cylinders to the ordinary type of compound condensing direct-acting engine, when the conditions of investment of capital forbid a much more costly type of compound engine. The theory of cut-off in this type of pumping engine seems to be that a certain percentage of the stroke at its terminal end may be cut off, regardless of the distance this point may be from the beginning of the stroke, and, therefore, the length of the stroke of the engine comes into play as an important factor in designing the best proportion of engine for any particular service, the arguments put forward by different makers failing to agree as to the length of stroke desirable, although there is little doubt that the number of strokes per minute is quite as prominent a factor of high efficiency as the feet traveled per minute. After being released from the high pressure cylinder the steam passes through reheating receivers to the intermediate cylinder, where it follows the piston full stroke; is again released, passes through a second reheating receiver and into the low pressure cylinder, where it also follows the piston throughout the stroke; is again released and goes to the condenser. The intermediate and low pressure cylinders are steam jacketed, the high pressure cylinder being without such protection.

The main valves of all the cylinders are driven from wrist plates, as in Corliss engines, the cut-off valves of the high pressure cylinder being operated by means of a pair of sliding blocks fitted to a sort of rocking "V," these blocks being capable of simultaneous adjustment by means of miter gears and a hand wheel, so as to vary the point of cut-off to suit the speed of the engine. The wrist plates which actuate the main valves are driven from rock shafts, these rock shafts being driven in turn, as is usual in the "duplex" machine, by having each side of the engine drive the main valves for the opposite side. The cut-off valves are driven from the same rock shafts, but so connected that each side of the engine operates its own cut-off valves. A feature worthy of note is the arrangement of the pins on the rock shaft arms from which the valve-gear is given motion, these pins being enlarged above the ordinary to an extent which permits of the driven rod passing directly through the body of the pin, thereby retaining all pressures directly in the center lines of force and entirely removing any tendency to bend or spring the rods.

The intermediate and low pressure steam cylinders are fitted with cushioning valves in the usual manner, but their use may be entirely obviated by the proper adjustment of the point of cut-off in the high pressure cylinders to suit the engine's speed, the cut-off valves being adjustable as a group or each individually, so that irregularities of strokes may be corrected at any single point without interfering otherwise with the operation of the engine.

In connecting the steam pistons, the high pressure and intermediate are attached to a single rod which extends through the forward head of the intermediate and the back head of the high pressure, then out through the front head of the high pressure; metallic packing being used in the stuffing boxes; the rod is then secured to the main cross-head, which rides upon a shoe running in a guide between the steam and water ends of the engine. The back head of the intermediate cylinder has no opening through it, and is removable into the low pressure cylinder, the intermediate and low being butted and secured together. The low pressure piston is attached to the main cross-head by means of long side rods passing out through the front head of the low pressure cylinder within the annular space defined by the difference in diameter between the low and intermediate cylinders, thence the rods pass forward until they reach the cross-head.

Another peculiar and rather commendable feature of the engine is found in the heavy cast-iron bed-plates extending under the entire steam ends; these bed-plates being solidly bolted to the foundations, and the cylinders permitted longitudinal movement upon the pedestals formed upon the bed-plates, so as to compensate for expansion and contraction; the water ends being securely bolted to the foundations.

The condensing apparatus consists of a jet condenser, with an independent single cylinder steam-driven air pump with a steam-thrown valve; a part of the overflow from the air pump is diverted into a small hot-well, and thence taken by an independent boiler feed pump and sent to the boiler; the exhaust from the steam ends of the air pump and the boiler feed being economically utilized through the medium of a feed water heater. The injection pipe leads from within the screenbox of the main suction pipe so that a sudden and undue drop in the water level in the well will rob the condenser of water and so break the vacuum before the main suction is in danger of losing its water. This is especially desirable for the reason that the river is at times

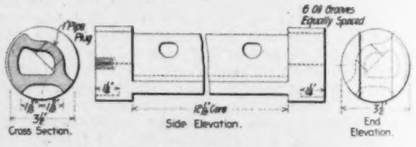

Fig. 12.—4-in. High Pressure Steam Valve.

heavily charged with water-soaked sawdust from mills above, which will at times completely obstruct the screens.

In following the design of the engine it will be seen that the low and intermediate cylinders are butted solidly together; the intermediate and high pressure are secured to each other by distance pieces, allowing easy access to the packings of the piston rod, also permitting the removal of the high pressure back cylinder head; the front head of the intermediate also being removable into the space between the cylinders. In the arrangement of the pumps proper, the structural connection between the front end of the high pressure cylinders and the water end

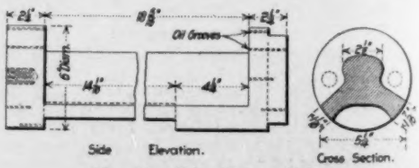

Fig. 13.—6-in. Rotary Valve.

is by heavy cast-iron frames, these frames supporting the rock-shaft bearings, and also the cross-head guides, leaving convenient access to the various details.

The cross-head is of cast steel and is carried upon a bronze shoe, thus relieving the piston and

*Consulting Engineer, 39 Cortlandt St., New York city.

plunger rods of all cross straining due to weight. It is made exceptionally heavy and strong, thereby affording ample strength and at the same time adding to the inertia of moving parts. The middle eye of the cross-head is of two sizes, one taking the high pressure piston rod and the other the main plunger rod; the outer eyes being provided for the low pressure rods.

The water end consists of two separate pumps of the regular construction generally found in this class of work, but with liberal valve area permitting probably with the limited suction lift here found, a speed of 50% in excess of that called for in the contract. The pumps are heavy enough to carry 100 lbs. pressure continuously in case of fire. A special feature of the water end is the location of the cross suction pipe directly beneath the outer ends of the pumps, so as to reach the supply well without undue deflection, and also to make a clear and clean floor about the engine possible. In carrying out this feature, partly made necessary by the limited space lengthwise of the engine, the pumps are arranged to overhang the foundations nearly half their length, this overhang being met by the introduction of heavy I-beams which extend from the shortened foundation to a thick stone wall forming a part of the older and original building.

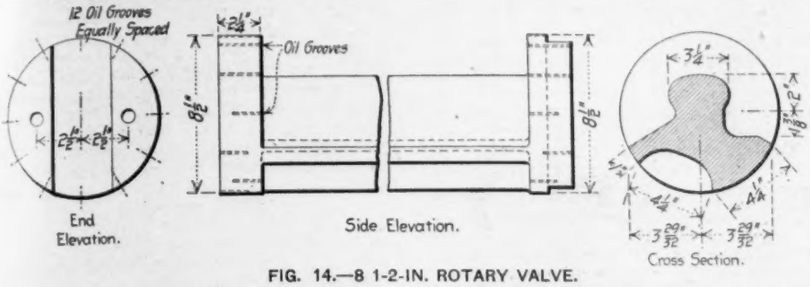

FIG. 14.—8 1-2-IN. ROTARY VALVE.

Some peculiar characteristics of the water of the Oswegatchie River in the shape of coarse sawdust, etc., make it desirable to use unusually efficient screens, and to let all surplus water flow by, the pumps only taking through the screens the actual quantity of water sent into the distribution, instead of attempting to screen all of the water entering the well. To effect this result, and at the same time afford ready access for removing and clearing the screens without interfering with the running of the engine, a special design of screen box with very liberal areas of screening surface is used, the passage of water through the meshes of the screens being at the rate of about 0.1 cu. ft. per second per square foot of screen, with the engine at full speed. It has been found by experiment that this rate of flow will not produce sufficient current to overcome the gravity of the water-soaked impedimenta, so that the worst that can happen would be a very slow accumulation of refuse at the bottom of the well, and provision is made to remove the most of this during the operation of the engine, by the use of a 12-in. "blow-out." The screens are of iron wire, ⅛-in. mesh.

In the main pumps, owing to the tannic acid qualities in the water, the plungers and rods are covered with brass, the pump sleeves through which the pump is worked are lined with brass, and all of the essential features of the pump valve outfit are also of brass.

The cross-delivery pipe is located midway of the length of the pumps, has easy curves, and joins the main delivery pipe at the left-hand side of the water end, this main pipe of 20-in. diameter being provided with a check valve opening downwards, and a gate valve just below the check, the pipe passing through the floor and out of the building through the basement wall. The hand wheel of the gate is within easy reach of the floor, and the entire arrangement apparently reaches the height of convenience and economy of space, the latter item having been held constantly in view on account of the environment.

The top speed is fixed by means of an automatic pump governor, so that it is impossible for the engine to "run away" by a sudden or considerable decrease of the water pressure. There has been no formal duty test made as yet, because of the reluctance of the city authorities to interfere with the engine in its regular service, during the refitting of the rest of the plant which is now going on, but the preliminary experiments indicate that 80,000,000 foot-pounds duty will be slightly exceeded, the guarantee under the contract being 75,000,000 per 1,000 lbs. of steam.

There is also being installed in this plant a pumping engine to be driven by water power, of unusually large size, possessing some special features to adapt it to the situation, embracing special arrangements for the admission and screening of the water, suction and delivery pipes, etc. This "power pump" is to be operated by two 48-in. turbine wheels, with the transmitting shafts fitted with friction clutches so as to meet the exigencies of domestic and fire services under "direct pressure" with promptness and certainty.

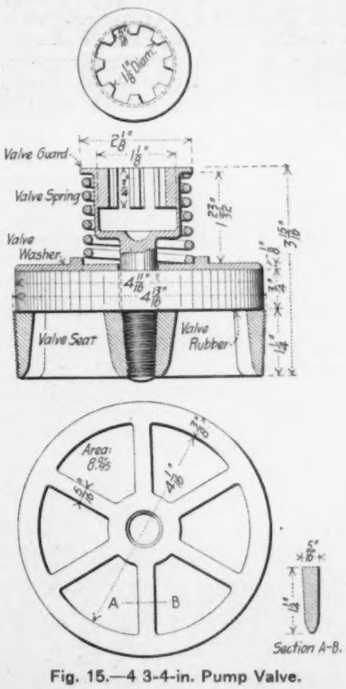

Fig. 15.—4 3-4-in. Pump Valve.

SPECIFICATIONS FOR STRUCTURAL STEEL AND RAILS.*

By Wm. R. Webster, M. Am. Inst. M. E.

The specifications for American structural steel and rails are, on the whole, very satisfactory. Some, of course, are behind the times; but common practice of to-day gives a much better material than they call for. On the other hand, there are specifications in which the physical and chemical requirements do not agree, or that call for an extremely high elastic limit or other results, which cannot be obtained by the ordinary methods of manufacture and testing. Specifications of this kind cause the manufacturers temporary trouble, but soon adjust themselves, either by the engineer coming out frankly and modifying them, or giving instructions modifying the point at issue, though still adhering to his printed specification. The latter method is much to be regretted, as the specifications are very misleading and the steel accepted under these modifications never has and never will meet the original requirements.

Our government specifications, at first, gave the manufacturers considerable trouble; but when they found that the requirements of these specifications had to be lived up to in every particular, they were forced to improve their methods in each department, and, as a result, there has been a gradual improvement in the quality and finish of structural steel, due to more uniform methods of manufacture, the most important being the control of the finishing temperature, as more steel was formerly spoiled by being finished at too high temperature than in any other way.

The quality of steel depends (1) on its chemical composition; (2) on the treatment it receives in the course of manufacture; and we are learning year by year better to distinguish the results due to each. To-day, at some of the mills, they are getting results that were formerly considered impossible. I refer to rolling the steel into finished product which meets all the requirements of the most rigid specifications, without stopping to make any preliminary tension test whatever. The steel is not allowed to get cold from the time it is cast until it is rolled into the finished product. This, of course, is a great saving of fuel and increases the output. This great advance has been brought about by close observation of the methods of manufacture and the establishment of the relations between the chemical composition and the physical properties. The analysis of each heat is made while the ingots are still in the soaking-pit. The ultimate strength is estimated from its chemical composition, then the heat of steel is rolled on orders where it will apply, due allowance, of course, being made for the thickness of the finished product.

I have made a special point of the heat treatment of steel in connection with work, as the quality of the finished product depends more on it than is generally admitted or understood, and I consider that it is now the most promising field of experiment and research. To-day we hear less of the mysterious failures of steel than ever before, as when a failure occurs in the shop or elsewhere, examination shows that in nearly all cases the trouble has been caused by improper treatment, and indicates the necessary improvements required in shop methods to avoid a recurrence of the trouble. In order to prove this, good material has been taken and similar failures have been produced at will by the same treatment. This has brought about in many shops as great an improvement in their methods of working the steel as in its manufacture. The net result of all this is that the consumer is to-day getting a better structure than ever before.

Recent careful scientific investigations have given us valuable information of the character and properties of steel, but there yet remains the important work of showing the direct relation between the results of these investigations and the every-day processes and results obtained in our mills and shops.

There is considerable room for improvement in our ordinary methods of testing structural steel. The conditions under which tests are made should be reduced to a standard as regards the pulling speed and the relation of the width of test piece to thickness of the material. About three widths would be sufficient to cover all ordinary thicknesses and they could be used without materially increasing the cost of the present methods of preparing test pieces. We also need some simple machine for making impact tests, as our ordinary tension tests do not give us all the information required as to the quality of the material to resist shock.

Too much importance is paid to the quench bends. In some cases the cold bends have been entirely omitted and the quench bends considered a reliable test as showing the quality of the material. Now this is all wrong; as soft steel which has been finished at too high temperature, and thus rendered brittle so that it will not stand the ordinary cold bends, may be restored by the heating, and the carbon being so low that the subsequent quenching does not harden this class of material, it then bends 180° flat on itself. Material accepted under these conditions has failed under subsequent shop work. Such material would have been rejected at the mills had the ordinary cold bends been made.

*From a discussion before the Franklin Institute, Philadelphia, Nov. 23, 1898.

THE POSITION OF PITTSBURG IN THE STEEL trade is thus stated by Mr. Andrew Carnegie, at a recent banquet tendered to him by the Pittsburg Chamber of Commerce:

There is not a district in this world to which the Pittsburg District cannot to-day send steel and pay the freight and deliver that steel as cheap or cheaper than it can be made at the point of delivery, if we except Colorado, to which the freight is greater than the difference in cost of manufacture at the two points. Should the South be successful in its present attempt to manufacture steel, we may have to except another point. Colorado excepted, the Pittsburg District has the whole world to-day at its feet. Pittsburg is indeed the steel city. I believe Pittsburg to be the best distributing point in the United States. She sits here, with one wing covering the East, the other the West, her beak dipping into the lakes upon the North, and her tail flapping in the Gulf of Mexico in the South. All points of the compass are within her easy reach and all tributary to her. She has that surest element of all for success, an enormous home market for her raw products and the largest army of the most efficient skilled labor in the world.

SPECIAL FEATURES OF THE RESERVOIRS AT THE CAMBRIDGE, MASS., WATER-WORKS.

Within the past few years the city of Cambridge, Mass., has made some extensive improvements to its water-works. Among these are two new reservoirs, storage and distributing, respectively. The Hobbs Brook storage reservoir has a capacity of about 2,500,000,000 gallons, a water surface of 558 acres, and a drainage area of 6.6 sq. miles. The reservoir filled for the first time in a remarkably short period, or between Dec. 16, 1897, and Aug. 20, 1898. The rainfall meanwhile was 33 ins., 71½% of which was, therefore, impounded.

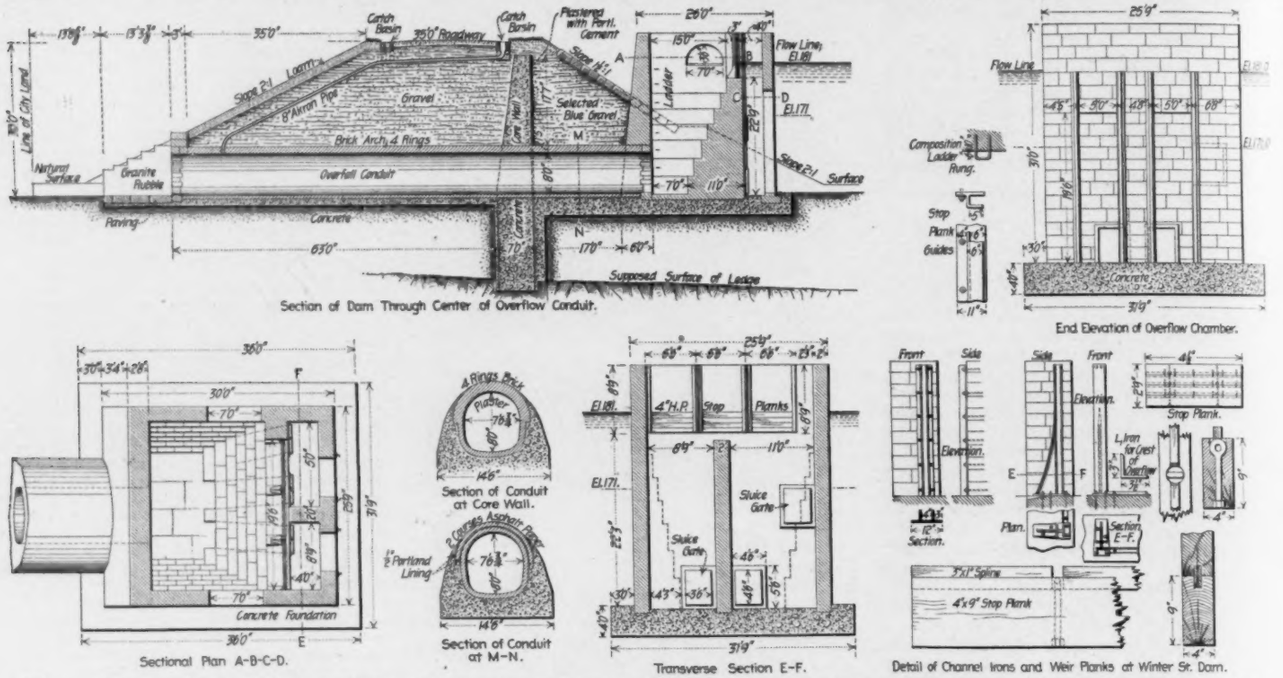
Section of Dam Through Center of Overflow Conduit.
End Elevation of Overflow Chamber.
Sectional Plan A-B-C-D.
Section of Conduit at Core Wall.
Section of Conduit at M-N.
Transverse Section E-F.
Detail of Channel Irons and Weir Planks at Winter St. Dam.

FIG. 1.—DETAILS OF AERATING AND OVERFLOW CHAMBER AND OVERFLOW CONDUIT, HOBBS BROOK RESERVOIR, CAMBRIDGE WATER-WORKS.
Mr. L. M. Hastings, City Engineer.

Overflow and Aerating Chamber, Hobbs Brook Reservoir.

The water from this reservoir flows down the natural bed of the stream, reaching it through the overflow and aerating chamber and the conduit extending through the dam, shown in detail by Fig. 1. Views of the chamber are also shown by Figs. 2 and 3. When the water level rises to a point 3 ins. above the stop planks on the aerating weir it flows through the arched openings at the side of the chamber. When it reaches an elevation 3 ins. higher still the storm relief overflow, or waste weir, 25 ft. in length, comes into service. This waste weir is shown at the left, in Fig. 3.

It may be added that the entire bed of this reservoir was stripped of soil and muck, necessitating the removal of some 1,900,000 cu. yds. of material, nearly all of which was handled by carts at from 16 to 22 cts. per yd., the latter price being paid for most of the work. This, we presume, explains the presence of the boulders in Fig. 3, although some of them may have been hauled in for the slope paving.

The Payson Park Reservoir, Gate House and Asphalt Lining.

There is a fine gate house at the Payson Park reservoir, as shown by the view, Fig. 4. The most interesting feature of this reservoir, however, is the asphalt lining, which was recently exposed for the first time after having been covered with water for about two years. The bottom of the reservoir was originally composed of 6 to 9 ins. of concrete. This proved to be of inferior quality, but as it seemed too good to tear out it was covered with asphalt. The concrete was first thoroughly swept. Then a thin coat of refined Bermudez asphalt, 95% pure, was applied with mops and brushes, as a binder. After this a lining of ½-in. of hot Bermudez asphalt concrete was applied. The concrete was composed of 50% of refined asphalt, 90% pure; 46% of limestone dust, and 4% of flux. This was slung on from dippers, as shown by Fig. 5, the motion being something like that of a man swinging a scythe. Usually the mixture was applied in two or three layers before it was thick enough. The material was bought from Richard Upham, of New York, and applied by Simpson Bros., of Boston. The contract prices were as follows: Refined asphalt for priming coat, $40 per ton; balance, $27.75 per ton; both f. o. b. at Cambridge. Labor, priming coat, ¾ cts., and ½-in. coat, 3½ cts. per sq. ft.

The above information was obtained from Mr. L. M. Hastings, City Engineer of Cambridge, and engineer for this work, by a member of the editorial staff of this journal, who visited the Hobbs Brook reservoir last September. Mr. Hastings kindly offered, at that time, to send us some notes on the appearance of the asphalt lining upon exposure, which he did under date of Oct. 1, as follows:

> The asphalt lining of the bottom for the most of the area looks finely, just as well as the day it was laid—bright, sound and hard. Across one end and near the partition wall, however, a very curious thing happened. Numerous blisters appeared in the black lining, which appeared lifted or blown up away from the concrete floor in sizes from 4 or 5 ft. in diameter to 2 or 3 ins. These lifted up to a surprising height, 2 or 3 ft., I should think in some cases, until the sheet of asphalt, originally ½-in. thick, was drawn out very thin. These burst or were punctured and then subsided with a wrinkled appearance. They were all filled with water. From 11 to 13 ft. of water was kept in the other part of the reservoir. The cause of this action is undoubtedly one of two things, or perhaps a combination of each: The inward pressure of ground or spring water, or the pressure of the water from the other compartment of the reservoir, which may not be pefectly tight. When the reservoir was built no water was encountered in the bottom, and so no underdrain was laid. Where the lining of asphalt was not subject to this outside influence, it is in a highly satisfactory condition.

METHODS OF SECURING WATERTIGHT WORK IN SHIP CONSTRUCTION.*

By H. G. Smith.†

It is an impossibility to make all compartments of a vessel absolutely watertight; they can only be made practically so, and when a certain degree of perfection is reached it is a waste of time and labor to proceed further. However, in order to secure practical watertightness, it is necessary to demand absolute watertightness, discretion being left

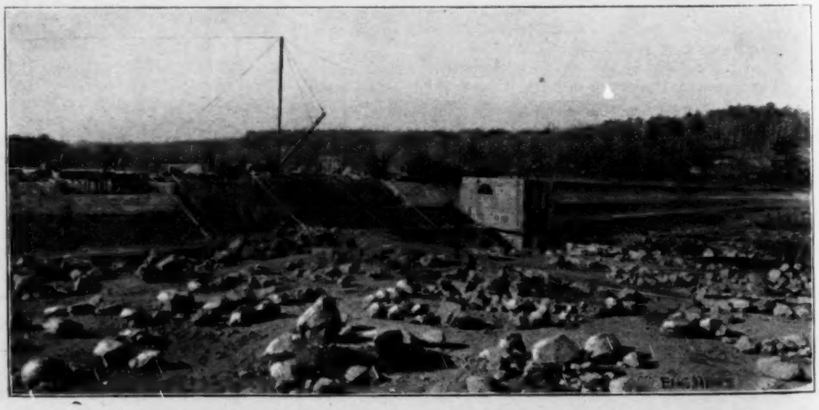

FIG. 2.—VIEW OF DAM, UNDER CONSTRUCTION, INCLUDING OVERFLOW AND AERATING CHAMBER AND WASTE WEIR.

*Abstract of paper read at the sixth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, Nov. 10 and 11, 1898.

†Assistant Naval Constructor, U. S. N., Philadelphia, Pa.

to the Inspection Officer to say when a test is satisfactory. A slight weeping of rivets or joints is immaterial, and more damage is often done in trying to repair them than by leaving them as they are. All compartments that are unsatisfactory at the first test should be refilled after having been stiffened if necessary, and thoroughly recalked throughout.

Specifications require that all material shall be calked metal to metal where possible. This is done either by hand or by pneumatic tools, and, when carefully done, I have been unable to detect any difference in the character

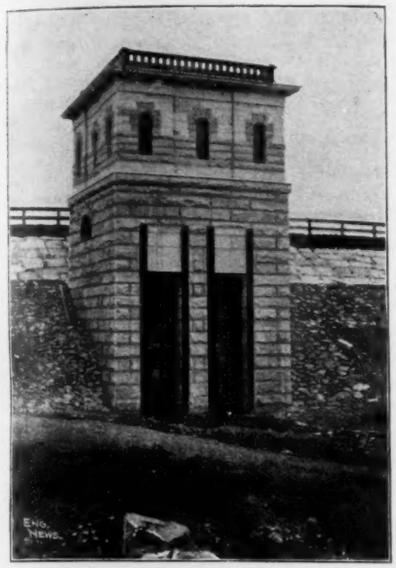

Fig. 3.—View of Overflow and Aerating Chamber.

of the work in the two cases as far as watertightness is concerned. The custom of chipping the edge of an angle bar before calking appears to be unnecessary. Equally good results were obtained on the U. S. S. "Alabama," where the bars were chipped and calked and where simply split and calked. There are many cases where it is necessary to adopt other means than calking for securing watertight work. Some joints are never accessible for calking after the material is fitted and riveted; while others do not prove satisfactory if calking alone is depended upon. Watertight floors in wake of liners on outside plating and inner bottom; bulkheads or decks, in wake of plating of two or more thicknesses; the connections of framing behind armor to the armor shelf, are examples of the second case, and require the use of stopwaters. Various substances are used for this purpose, amongst which may be mentioned the following, viz:—Tarred hemp felt, plain or soaked in red or white lead; canvas soaked in red or white lead; sheet rubber; sheet lead; red lead putty; hempen or lamp-wick gaskets, soaked in white lead; asbestos; lead wire, and in some cases copper wire. Any one of these is satisfactory in a particular case, but different classes of work require different stopwaters. Where the joints of material are close fitting, or can be well drawn together in riveting, a strip of tarred hemp felt is generally used. This is the case with most of the lighter material, one-half inch thick or under, in hull work. Where the parts connected are very rigid, and are apt to stand some distance apart when riveted, a layer of felt is next to useless, as, being thin, it is not compressed between the plates. In these cases a thick layer of some plastic substance, such as red-lead putty, should be used. This will fill all the spaces between the parts as they are drawn together, and on hardening will form a solid joint. Rubber, lead, canvas, asbestos, etc., are principally used in connection with pipe work. In order more thoroughly to test the efficiency of the various materials used as stopwaters, the following experiments were made:

A cast-iron bend was fitted with blank flanges, in each of which holes were cut, over which smaller flanges could be fitted, using different materials as gaskets. This improvised water tank with its flanges was placed in the open air, where it would be exposed to all kinds of weather. A stand-pipe, fitted with a funnel at its upper end, and about 35 ft. high, was connected to the tank. Water was poured in and the flanges set up until they were quite watertight under a pressure head of 35 ft. The tank was allowed to stand about 3½ months, water being added at intervals to maintain the pressure. At the end of this time all joints were broken, an examination made of the stopwaters, and their condition found to be as follows:

(1) Tarred hemp felt, plain; in thoroughly good condition, no leakage having taken place. (2) Canvas soaked in red lead; quite dry and in thoroughly good condition. (3) Asbestos; some leakage, and where this occurred the material was moldy and partially decayed. (4) Red-lead putty; thoroughly dry, being frozen to the metal, making practically a solid joint. No leakage had occurred. (5) Tarred hemp felt soaked in red lead. The joint was in good condition, except in one place, where a slight leak had occurred. At this point the felt was slowly working out of the joint. (6) Rubber; this gasket had squeezed out somewhat at the edges, and had lost its elastic qualities, but was still effective.

All the joints were now made up anew, light plates that would admit of deflection being used instead of the heavy flanges, and each joint made with new material of the same class as before. After watertightness had been secured with 35 ft. pressure head, the bolts in each flange were eased off until a slight leakage took place. The apparatus was allowed to stand about two months, water being added frequently to maintain the pressure. It was then disconnected and the joints re-examined. The results were as follows:

(1) Tarred hemp felt, plain; slightly rotted. (2) Canvas soaked in red lead; in very good condition, no decay. (3) Asbestos; moldy and somewhat decayed. (4) Red-lead putty; in excellent condition. (5) Tarred hemp felt soaked in white lead; considerably decayed, but not in bad shape. (6) Rubber; somewhat decayed.

Although not extensive nor of sufficient duration to be entirely satisfactory, these tests show in a general way what may be expected of the above materials; that all of them may be used in particular cases and some of them in any case liable to be encountered in ship construction. Red-lead putty is an excellent stopwater, and can always be relied upon. It should be used where there is any doubt as to the proper one needed. It can be made by mixing dry red lead with white-lead paint.

Tarred hemp felt generally makes a very good stopwater if used with discretion. Where constantly subjected to the action of water, however, it is liable to be squeezed out of the joint. Canvas soaked in red lead makes an excellent gasket for sea-valve connections to outside plating or in the joints of piping. Asbestos is used where joints are subject to heat and some substance not easily burnt out is required.

Natural Rust Joints.—Where the parts have not been painted, as between a rivet and the edge of the hole, rust joints will form in a very short time after the application of water pressure, which, if the leaks be but slight at first, will soon become quite tight. If left to themselves, many of the trifling leaks will thus soon disappear. Although not a desirable way of producing watertightness, rust joints cannot be prevented from forming, and the results are satisfactory. I have not ascertained that any material damage has been produced from this cause, but it shows the importance of painting as far as possible all faying surfaces of material, as it is fitted, to prevent corrosion, which will otherwise occur and which might prove serious. It is preferable to test all compartments before they are painted, as the leaks are more easily located.

A coat of paint, or a layer of cement, however, has very little effect in stopping a leak. In two or three cases where compartments were tested in very cold weather, even a heavy coating of ice was insufficient to keep the

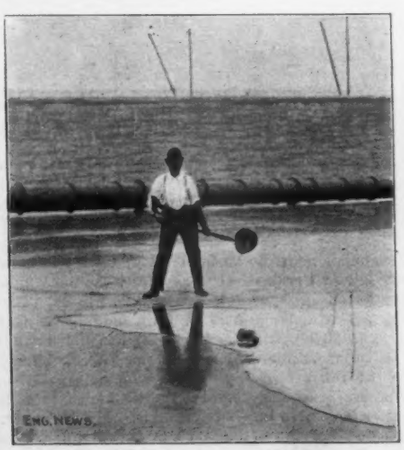

Fig. 5.—Placing Asphalt Lining on the Payson Park Reservoir, Cambridge, Mass.

water from oozing through under pressure, where leaks occurred.

All countersunk-head rivets should be calked at the head. My experience has been that the head of a countersunk rivet is very rarely tight unless calked. This is due to the fact that the angles of countersink on the rivet and in the plate are somewhat different, the head of the rivet not entirely filling the hole unless very carefully driven. The difference between the case of the countersunk head and the pan head rivet, then, is, that the former is apt to bear against the plate along a line only, and not over a surface, as in the case of the pan head rivet, with consequent greater danger of leakage. Again, the head of a countersunk rivet usually projects beyond the hole, and if leakage occurs, it is generally necessary to chip off the head before the same is accessible for thorough calking. I consider it desirable to avoid the use of these rivets as much as possible.

In bulkhead work much better results are obtained by

Fig. 4.—View of Gate House, Payson Park Reservoir, Cambridge, Mass.

lapping the butts and seams than by strapping them. Bounding angles and all staple angles and collars should be fitted double, i. e., on each side of the bulkhead. For good results this is imperative. When fitted on one side only the calking is invariably broken when the pressure is applied on the calking side, and it is necessary to fit additional staples or plate collars to remedy this after the bulkhead is completed and tested. The plates, as far as possible, should have their seams parallel throughout. The stiffeners or girders should be fitted in the direction of the shorter length. It is not advisable to fit a horizontal girder or stiffener on a very long bulkhead, unless the same can have cross ties to other bulkheads. Greater stiffness can be attained by putting the same weight of material into a number of shorter vertical stiffeners. If single bounding bars be used, the butt straps to same should be on the opposite side of the bulkhead from the bars themselves, with a liner fitted at the back of the bar at the bottom of the plate, and the ends of the bar calked. Flanged brackets at the bottom of stiffeners give less satisfaction than brackets and angle clips, as the flanged plate has a tendency to straighten when the stiffener is in tension. At the top of a stiffener, where there is less pressure, a flanged plate is generally satisfactory. When stiffened principally on one side, the bulkhead apparently stands better when deflected away from the stiffeners than when toward them.

Summarzing the conclusions already reached, there are certain very important features which, if more generally adopted, will undoubtedly give a much more efficient watertight subdivision of vessels. These are:

(1) Fitting of efficient rigid bracketing to all stiffeners on bulkheads below the water-line. (2) Fitting of double bounding and staple angles to such parts of all bulkheads as may be below the water-line. (3) Fitting of a vertical stiffening bar or double staples on all water-tight floor plates of a certain size (depending upon the class of vessel), except where the plate is in direct line and adjacent to a bulkhead above. (4) Fitting of the protective deck in two thicknesses instead of three. (5) Fitting of all plating behind armor in one thickness instead of two. (6) The use of double riveted lapped butts and seams instead of strapped butts and seams in the case of the inner bottom, platform and splinter decks and all bulkheads. (7) As an alternative to No. 6, the fitting of a stuffening bar along the seams in the case of all light flush plating fitted with straps.

The first three of these items are imperative, Nos. 4 and 5 very important, and the others desirable. In connection with these must be mentioned a general increase in the stiffness of certain important bulkheads, as already discussed. This I consider the most important feature of all.

THE HEILMANN ELECTRIC LOCOMOTIVE.

About five years ago there was heralded to the world the introduction of a self-contained electric locomotive on a French railway, which was in effect a combination of power station and motor car, and was claimed to combine exceptional properties of speed, power and economy. This machine was invented by Mr. J. J. Heilmann, of the Heilmann Works, manufacturers of steam and electric plant, of Paris, France. The technical papers were not enthusiastic over the design, an analysis of which failed to show advantages commensurate with the disadvantages. The machine was tested in experimental and regular train service on the Western Railway, under the supervision of Mr. Clerault, Superintendent of Motive Power, and "satisfactory" results were reported. In 1896, two more machines, of improved design, were built, and have been tried on the same railway, but the results of these trials have not been made public.

We have recently received from Mr. Drouin, Engineer of the Heilmann Works, particulars of these engines, and the following description of the old and new locomotives will interest many of our readers. We also reproduce herewith a photograph of one of the new locomotives, which shows also a special water-tank car which is attached for long runs. It will be seen that in its external appearance the machine would impress the average observer as a cross between a snow-plough and a military car for a Cuban railway.

VIEW OF THE HEILMANN ELECTRIC LOCOMOTIVE AND ITS WATER CAR ON THE WESTERN RAILWAY OF FRANCE.

The first locomotive on this system, named the "Fusee Electrique" (or "Electric Rocket") was tested in 1893-94 (Eng. News, March 15, 1894). It had a heavy girder framing, and was mounted on two eight-wheel driving trucks. At the rear end was a Lentz boiler, with water tanks on each side, while at the forward end was a 600-HP. horizontal compound steam engine (placed transversely to the longitudinal axis of the machine) running at a speed of 360 revolutons per minute. The engine drove a six-pole dynamo furnishing current to eight motors (one at each axle), while another engine drove a small exciter of constant potential. The engine was controlled by varying the exciter current by means of a rheostat, and was reversed by means of a commutator which reversed the current. The forward part of the engine was enclosed by a large cab. The weight of this engine was about 114 tons, or an average of about 7 tons per wheel.

According to the report made by Mr. Clerault to the International Railway Congress of 1895, the engine has hauled a load of 420 tons for test, and has also hauled trains of 206 tons and 80 tons (exclusive of the engine) at 21⅛ miles and 29½ miles per hour, respectively, on a grade of 0.8%, 7½ miles long. This was in experimental service on the line between Havre and Beuzeville. On the line between Paris and Mantes, 34.7 miles, the engine hauled regular and experimental trains of 60 to 80 tons at regular express speeds, the maximum speed recorded being 67 miles per hour. The engine was said to be very steady on the track. The coal consumption was gradually reduced from 24.5 to 13.2 pounds per mile. For five trips with trains of 61 and 69 tons (behind the engine), the average consumption was 20 lbs. per mile; 0.114 lbs. per mile per ton of total load (173 to 183 tons), or 0.323 lbs. per mile per ton of net train load (61 to 69 tons).

In 1896, two more of these engines, but of greater power, were built by the Call Company to the design of the Societe de Traction Electrique. These locomotives, as shown by the accompanying cut, are in general similar to the first, having an iron underframe mounted on two eight-wheel driving trucks, with the engine and dynamo at the forward end and the boiler at the rear end of the frame. The wheels are 3.8 ft. in diameter. A metal cab is built over the machinery, and is brought to a point at the front to lessen the air resistance. The total weight is 120 tons, or 7½ tons per wheel, but the machinery has a much greater capacity than that of the former locomotive, having a steam engine of 1,350 I. HP. as compared with 769 I. HP. It is to be noted, however, that for long runs the new engines have to haul specal cars, mounted on two four-wheel trucks and carrying 24 tons of water. One of these cars is equipped with four electric motors, and may be used as an extra engine in hauling very heavy trains.

The new 120-ton locomotives are 61 ft. long over the frames, 8 ft. 10 ins. wide over all, and 13 ft. 9 ins. high from the rail to the top of the smokestack. They have a total wheelbase of 50 ft. 6 ins., the truck wheelbase being 13 ft. 6 ins. The boiler is of the locomotive type, with Belpaire firebox, and is fixed at the middle, the ends being supported on expansion bearings. It has 351 tubes, 1¾ ins. diameter and 12 ft. 6 ins. long. The grate area is 36 sq. ft., and the total heating surface, 1,995.6 sq. ft., of which latter the interior surface of the tubes represents 1,818.4 sq. ft. The coal bunkers are on either side of the boiler, and the water is carried in a tender, as already noted. The engine is of the Willans vertical compound type, having six sets of tandem cylinders (or twelve cylinders in all), the high pressure cylinders being 12 × 16 ins. and the low pressure cylinders 19.2 × 16 ins. This engine runs normally at 400 revolutions per minute, the cranks running in a closed chamber containing oil and water. A separator on the steam pipe prevents water from getting into the cylinders.

At each end of the engine shaft is a six-pole dynamo, furnishing a current of about 1,000 amperes at 450 volts, or of double that intensity for a brief time. These dynamos are coupled in parallel. They are inclosed in steel casings, having suitable manholes and openings for ventilation. They were built by Brown, Boveri & Co. The exciting dynamo is a four-pole machine, which also serves to light the train, furnishing a current of 140 amperes at 115 volts. It is driven by a two-cylinder simple Willans engine of 28 I. HP., having cylinders 8.64 × 5.08 ins., and running at 550 revolutions per minute. On each driving axle is mounted a four-pole motor, rated for 125 HP. (or 1,000 HP. in all), at a speed of 62 miles per hour.

The machine is said to ride very steadily, owing to the absence of the ordinary reciprocating parts and to the balancing of its multi-cylinder vertical engine. Although it can develop considerable power, it does not seem capable of hauling very heavy trains, or of attaining any exceptional speed. One advantage claimed is an economy in coal consumption, but the information furnished us gives no particulars of any work in hauling heavy trains. An engine of 120 tons, with a huge tender in addition, ought to be able to do some real work, but we have no information as to the character of the tests or results obtained.

For general purposes, however, we may compare the figures already given for the first Heilmann electric locomotive with those of some new steam locomotives for fast passenger and freight service on the Great Northern Ry. These engines are of the ten-wheel type, having three driving axles. As shown by recent tests, they can haul passenger trains of 157 tons and freight trains of 417 tons at speeds of 49½ and 34 miles per hour on a division where the maximum grades are 2.2% and the average grade is 1.23% for 48 miles. The weight of engine and tender is 132 tons, and during the test the coal consumption was 152 and 241 lbs. per mile for passenger and freight trains, respectively, making 13.2 and 8.3 miles per ton of coal. From these figures we obtain for the passenger service 0.53 lbs. per mile per ton of total train, or 0.96 lbs. per mile per ton of the net train load. For the freight service the figures per ton per mile are 0.44 lbs. for the total train, or 0.58 lbs. for the net train. In comparing these figures with those of the "Electric Rocket" it must be remembered that the latter represented 62 to 65% of the total train load, while the steam locomotive (and tender) represented only 45.7% of its total passenger train, and 24% of its total freight train.

THE LOWELL TEXTILE SCHOOL.

The annual catalogue of the Lowell, Mass., Textile School for 1898-99, contains information which should be of interest not only to those connected with the textile industries, but to others who are students of educational and social science. In the recent address by Prof. J. B. Johnson, on "A Higher Industrial and Commercial Education" (Eng. News, Aug. 18, 1898), he criticised our existing educational systems as lacking in the very element which it is the object of such schools as the one at Lowell to furnish, viz.: a scientific training especially suitable for the manufacturing industries. In that address he said:

> The most essential conditions of our future material prosperity are, as I conceive them, a specific scientific training for the directors of each and every kind of manufacturing and commercial activity. The imperial and paternal government of Germany has worked out this problem to a most fruitful issue, but probably no other country could duplicate it. England has been trying for ten years to do so, but with poor success; instead of highly educating a few leaders and directors of industry and commerce, they are vainly trying to raise the whole class of apprentices and clerks by a wholesale system of shallow night-school instruction. The great question for us to solve is how to obtain a corresponding scientific training for our industrial officials.

This great question is the one which, as far as the textile industry is concerned, the Lowell school is attempting to solve. As far as we can judge from the catalogue, its plans have been laid broad and deep, with a full knowledge of the scope of the problem, and after a thorough study of the European textile schools, and of the textile school which is developing successfully in Philadelphia. The trustees of the school are incorporated by act of the Massachusetts legislature, and the incorporators are directors or officers of great textile corporations in the state, with an aggregate capital of over $25,000,000. The school was opened Jan. 30, 1897.

The object of the school is to give instruction in the practical knowledge necessary in the cotton, woolen, worsted and other textile industries, in

sciences and art as applied to these industries. The equipment consists of high grade machinery specially built to afford facilities for experimental work, and of such variety as is never found in any one textile mill. When all the machinery already arranged for is installed the equipment will be more extensive than that of any other textile

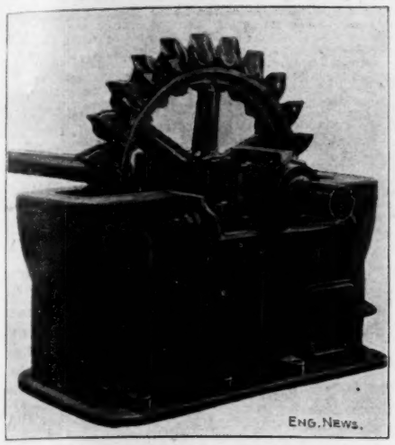

Fig. 1.—A New Impulse Water-Wheel. Patented by Daniel Hug, Denver, Colo.

school either in America or Europe. The work of the school is carried on in four directions: Day classes, evening classes, popular lectures, and women's department, each adapted for different sets of students. In the day classes there are four separate courses, each of which requires three years for its completion. They are: The cotton manufacturing course; the woolen manufacturing course; the designing course; and chemistry and dyeing. One term of preliminary instruction is given in the first year, consisting of principles of mechanism, machine drawing, textile calculations, elementary designing and elementary chemistry. Towards the end of this term each student elects which of the four regular courses he will follow in his subsequent studies. The evening classes are intended to give instruction to those who are engaged in the mills during the day, to enable them to perfect their knowledge of the branches in which they work, or to acquire knowledge of other processes. Five separate courses are given in evening classes covering the manufacture of cotton and woolen yarns, weaving on all varieties of looms; designing, cloth construction, analysis, and reproduction, color, and textile calculations; and chemistry and dyeing. Popular illustrated lectures on subjects connected with the textile industries are also given, and there are day classes for women in art subjects, especially in textile designing. The tuition fee charged for the day classes is $100 per school year, or $50 per half-year term. The fees for the evening classes vary according to the course. Tools, instruments, text-books, etc., for students in the day classes cost from $10 to $15. The plant of the school now arranged for will cost $75,000. That the school is already a success so far as number of students is concerned appears from the list of students, numbering 257 in all, of whom 72 are day students. Of the latter 3 are graduates of universities, 6 of schools of technology, 32 of high schools, 13 of grammar schools, and 18 passed entrance examinations, or gave evidence of proficiency.

The school staff is as follows: Wm. W. Crosby, S. B., Principal, and Professor of Mechanics; Fenwick Umpleby, Professor of Textile Design and Fabric Structure; Louis A. Olney, Professor of Chemistry and Dyeing; Edgar H. Barker, Professor of Woolen and Worsted Spinning; Charles C. Hedrick, Professor of Cotton Spinning; Vesper L. George, Professor of Decorative Art; William Nelson, Professor of Weaving. We are indebted to Prof. Barker for a copy of the catalogue.

We shall watch the future progress of this school with great interest.

TESTS OF A NEW IMPULSE WATER-WHEEL.

We illustrate herewith a new form of impulse water wheel, recently invented by Mr. Daniel Hug, of Denver, Colo., and covered by U. S. Patents Nos. 576,828 and 576,849, Feb. 9, 1897. The principal feature of this wheel, which distinguishes it from the Pelton and other impulse wheels in which the buckets are carried on the circumference of the wheel, is the form of the buckets. The form is clearly shown in the illustration. The nozzle is so placed as to throw the jet horizontally into a bucket which is at the lowest point of its travel, and the jet on striking the V-shaped partition in the bucket is split into two halves, which are diverted upward and outward by the curved form of the interior of the bucket. The discharging passage gradually contracts toward the outlet, so that it has to a certain extent the function of a nozzle, the flow of the water being thus retarded while its reactionary power is transmitted to the walls of the bucket. Another feature of Mr. Hug's wheel is a "protector," or frame, closely surrounding the bucket, and into which the bucket discharges the water, so that none of the water is thrown upwardly or carried over the top of the wheel.

Several of these wheels have been built by the Denver Engineering Works Co., Denver, Colo., and have given good results in practice. A 12-in. wheel was recently sent to Prof. R. C. Carpenter, of Cornell University, for a complete test with different sizes of nozzle and different heads. We have been favored with a copy of the report, which is one of the most elaborate reports of a water-wheel test that we have ever seen. Tests were made both with and without the frame, showing in some cases a considerable increase of efficiency when the frame was used, but in other cases the increase was unimportant. We give herewith some diagrams in which the results of some of the tests are shown graphically. The efficiencies reached over 85% when the conditions of load, size of nozzle, etc., were favorable, appear to us to be quite remarkable for so small a

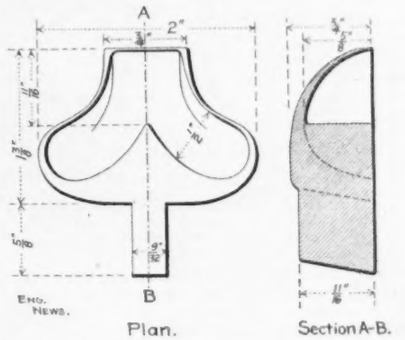

Fig. 2.—Elevation and Plan Drawn from Model of Bucket of Hug Water-Wheel.

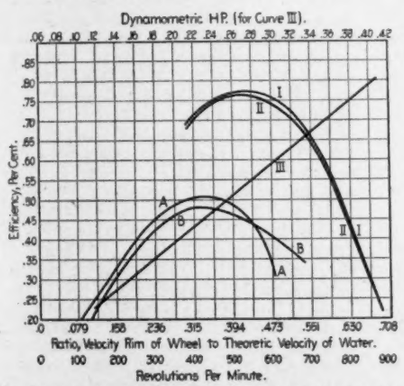
Dynamometric H.P. (for Curve III).
Efficiency, Per Cent.
Ratio, Velocity Rim of Wheel to Theoretic Velocity of Water.
Revolutions Per Minute.

Fig. 3.—Results of Tests of Hug Water-Wheel Under a Head of 57.66 ft.
Curves I., II., III.; Tests with 1-2-in. Nozzle.
Curves A, B; Tests with 1-4-in. Nozzle.

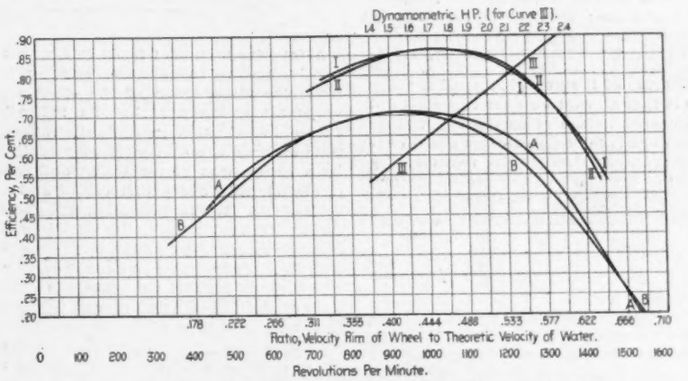
Dynamometric H.P. (for Curve III).
Efficiency, Per Cent.
Ratio, Velocity Rim of Wheel to Theoretic Velocity of Water.
Revolutions Per Minute.

FIG. 4.—RESULTS OF TESTS OF HUG WATER-WHEEL UNDER A HEAD OF 182.23 FT.
Curves I., II., III.; Tests with 1-2-in. Nozzle.
Curves A, B; Tests with 1-4-in. Nozzle.

Fig. 5.—Perspective Sketch from Model of Bucket of Hug Water-Wheel.

wheel. The range of power through which the efficiency remains high, as shown by the plotted diagrams, is also, we believe, exceptionally good. It is interesting to note that in all the tests the efficiency was directly proportional to the horse-power developed, as is shown by the inclined straight line plotted on each of the diagrams.

Mr. Oscar Knapp, 207 Ross St., Brooklyn, N. Y., is representing Mr. Hug in the East.

THE ATTEMPT TO FORM A POOL, or agreement, by the steel rail manufacturers has failed. Judge E. H. Gary, president of the new Federal Steel Co., said concerning it: "There was no idea of forming a pool. During the week the steel rail manufacturers of this country have been striving to reach a fair and equitable working agreement in regard to division of territory and prices. But at to-day's meeting it was found that it was not possible to reach an agreement, and the plan was abandoned. I think, however, that there is a disposition among steel rail manufacturers to live up to prices, while there is a lack of complete harmony of action just now."

The difficulty seems to have been the refusal of the Carnegie Steel Co. to enter the agreement on the terms proposed.

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A notable feature of the new charter of the city of Baltimore is that all contracts are to be awarded by a special board, instead of by the department for which the work is to be done. This board consists of the mayor, comptroller, city register, city solicitor and the president of the second branch of the city council. Proposals must be invited for all work and supplies costing $500 or over, and the contract must be awarded to the "lowest responsible bidder." It seems very doubtful, especially in view of the provision quoted, whether the advantages of this plan will equal its disadvantages. The function of the board is simply to decide who is the lowest responsible bidder. To what contractor the work must go, regardless of whether the lowest bid is too high to give a reasonable profit, only, or too low to secure good work. Perhaps some bidders will be more careful, under this plan, not to bid too low, since the board of award will not be able to show them any favors in the execution of the contract, without collusion between this board and the department having the work in charge. In fact, here seems to lie the principal advantage of the plan, possible increased difficulty in making "deals," because there are two sets of men instead of one to arrange with. But the check does not apply to the frauds which may be practiced in the execution of the work. As to who is the "lowest responsible bidder," the department in charge of the work is better fitted to judge than the board of award. Of course, the advice of this department can, and probably will, be secured. If its advice is followed, the board of award is likely to be a more or less perfunctory body. If its advice is not followed, and the final estimates promise to exceed the original ones, the department involved knows it can, at least, divide the responsibility with the board of award, and thus may be slack in holding the contractor to terms or avoiding extras.

The Heilmann locomotive power-station, or power-station locomotive, which we describe in another column, is one of the most ambitious attempts to apply electricity as a motive power in ordinary railway service which has ever been put into practice. Three engines have been built, two of which have been in use about twelve months, but no information as to their performance is available. Each engine consists essentially of a 1,350-HP. Willans engine, a large boiler, two 600-HP. dynamos, and eight 125-HP. motors, each motor being mounted on one of the driving axles. Great advantages in power, speed and economy are claimed, while the fact that the engine carries its own power plant makes it independent of conductors and central stations. In a brief discussion on the original Heilmann locomotive, in our issue of March 15, 1894, we took occasion to point out a fact that is often overlooked by advocates of electric locomotives. This fact is that the steam locomotive generates power at a much lower cost than any stationary steam plant. Mr. Heilmann uses what is practically a stationary plant, or power-station, which operates under the disadvantage, however, of being carried bodily from place to place. Some of the published accounts, however, state that the new engines were built for use on a certain branch of the Western Ry. If that is the case, it seems most probable that, if electric traction was desired, better economy could have been obtained by the establishment of a stationary central station and an overhead wire, or third-rail conductor, than by the use of the self-contained electric locomotive. It is easy to see, however, why this has not been done. The railway company is not likely to be considering the question of electrical traction except in a very general way, and has no intention of incurring expense for plant for this purpose. It has simply allowed the inventor of this machine to use a certain part of its tracks, and has directed its engineers to make careful tests of the performance.

A favorite argument made in favor of the electric locomotive as a future certainty, is that the extensive introduction of the electric motor car on street railways is but an indication of its future introduction in ordinary railway service. This argument, however, is very easily answered by a comparison of the traffic and requirements of electric railways with those of ordinary steam railways. A little investigation will show that, almost without exception, the electric motor car or locomotive operates under conditions which are entirely different from steam railway service, and which would prevent the economical operation by steam locomotives. The electric railways form in fact a class of themselves, and cannot be considered as ordinary railways which have adopted a new motive power. A frequent service of cars at certain hours on suburban lines or a less frequent service on country lines, cannot well be operated to advantage by ordinary steam locomotives, although the recent introduction of steam cars for light traffic on branch lines has opened a new field for the economical use of steam power. On elevated railways, electric traction can ensure certain economies, but an equally important consideration is the elimination of the noise and dirt from locomotives, which consideration has little or no bearing on ordinary railways. The electric locomotives on the Baltimore & Ohio R. R. are for hauling trains through a long city tunnel, to avoid the inconvenience and discomfort due to smoke from steam engines, but this work is not comparable with ordinary railway work. In fact, all electric railways thus far built have been for purely local traffic. So far as we know, the Heilmann engine is the only attempted application of electricity as a motive power for ordinary railway service, and it must be confessed that the published results give no reason whatever to expect more extended use of the machine. In view of the enormous capacity of modern steam locomotives in point of speed and hauling power, and in view of the close attention that is being given to means of obtaining increased economy in operation, we see no reason to expect the application of the electric locomotive to ordinary railway service.

The progress thus far made toward the creation of a commission to revise the building laws, as provided in the Greater New York Charter, is summarized as follows in a statement recently sent out by the Charity Organization Society:

A resolution was introduced some months ago, and has passed the Council, providing for a commission of eight members, of whom there shall be one carpenter, one ironworker, one plumber, one mason, one engineer, one architect, one representative of the Board of Fire Underwriters, and one representative of the Corporation Counsel, ex-officio. In the Board of Aldermen this resolution has been referred to a joint committee, consisting of the standing committees on Law, Public Health, and Public Buildings, Lighting and Supplies. To this joint committee has also been referred another resolution on the same subject, introduced by Alderman Folks. This latter resolution provides for a commission of 19 members, which is to include the three Commissioners of Buildings, the Chief of the Fire Department, a representative of the Corporation Counsel, ex-officio; a representative of the Board of Fire Underwriters, two representatives of the Tenement House Committee of 1894, a sanitary engineer, a civil engineer, five architects, two lawyers, and two practical builders. This proposed commission, therefore, consists of five representatives of city departments, seven experts (architects or engineers), two tenement house reformers, two lawyers and two practical builders.

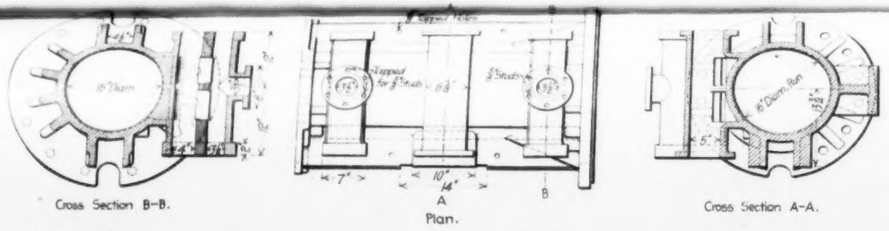
The Society strongly urges that the important work of revising the building code shall not be turned over to a commission constituted almost wholly in the interest of builders and contractors, as would be the case if the first-named resolution were adopted; and approves the commission provided for by the second resolution.

As we pointed out in our issue of Jan. 20, 1898, the excellence or the reverse of the new code will depend very much upon the character and ability of the commission which shall formulate it. Of the two commissions which are proposed, the larger will, we think, appeal to engineers and architects as presenting the greatest number of favorable features. The preponderating position of the building interests in the commission of eight and the manifest unwisdom of asking these interests to form a law for the regulation and restraint of their own business for the sake of the public health and safety, seem to decide its inferiority, as the Charity Organization Society well says. The commission of 19, while somewhat unwieldly in point of numbers, gives, on the contrary, due representation to all interests without giving a preponderating influence to any single one. It also provides the necessary strong element of expert knowledge in the large number of engineer and architect members, which it specifies. Further, the larger commission will permit a proper representation of the needs of the suburban and semi-rural portions of the city as well as those of the residence, tenement house, and office building districts. The value of the new code, after all is said, however, will depend upon the character and ability of the expert members of the commission. Many of the conditions of the present building laws can be remedied successfully by expert engineers only, who are thoroughly familiar with the latest advances made in the knowledge of the strength and endurance of materials, and who will apply this knowledge with an unbiased mind. Engineers can do much toward securing the appointment of such men, and if they choose to neglect the opportunity, they have little cause to blame anyone but themselves should the new code perpetuate the well-known crudities and unwise and oppressive restrictions that occur in the present building laws.

THE PASSING OF THE CANAL.

In our issue of Nov. 10, in commenting on the prospective abandonment of the famous old Delaware & Hudson Canal, we referred to the probability that a few years more will see the entire disappearance of the old-time canal-boat as a vehicle for freight transportation. Men now living can remember when the canals of the Middle States were important avenues for passenger transportation, as well as carriers of all classes of freight. The passenger traffic forsook the canals at an early period in the history of the railway; the general merchandise traffic soon followed; and for many years the only business left to the canals has been the carriage of the cheapest and coarsest class of bulk freights. Even in this field, however, the continual cheapening of rail transportation has gradually drawn business away from the canals. The Erie Canal during the pres-

FIG. 6. 23x36 IN. STEAM CYLINDER.



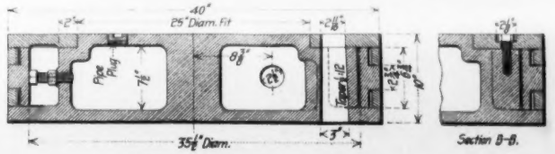


FIG. 10. 40 IN. PISTON.

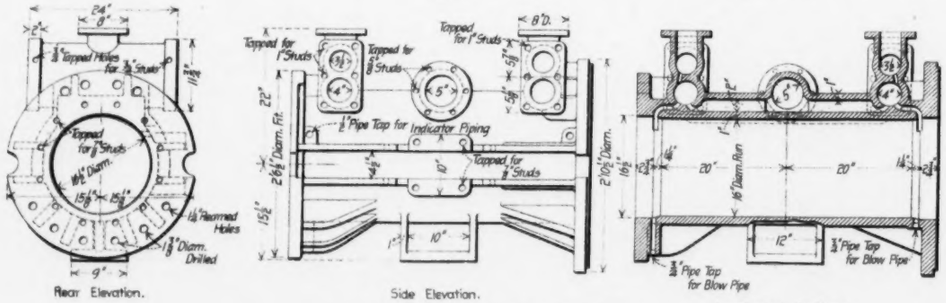


FIG. 5. 16x36 IN. STEAM CYLINDER.

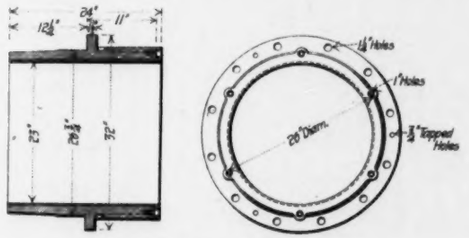
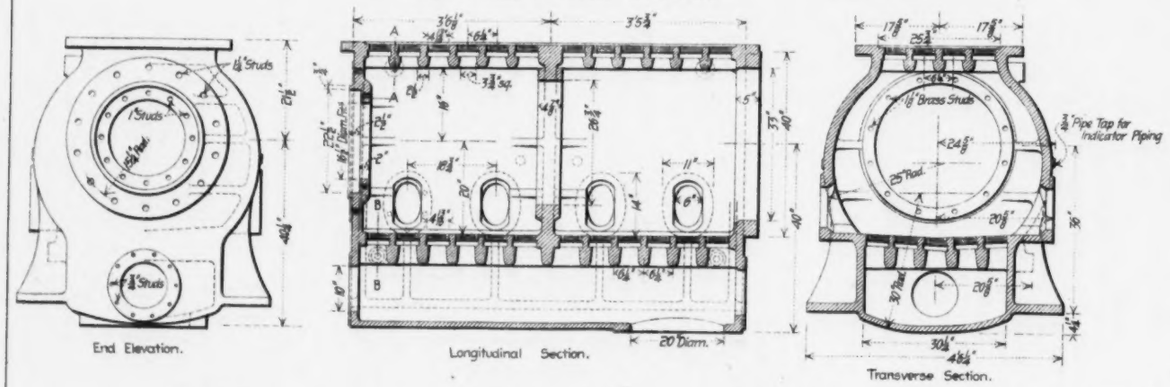


FIG. 4. 23 IN. PLUNGER RING.



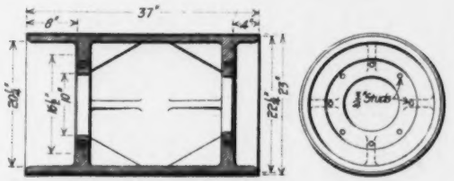


FIG. 3. 23 IN. PLUNGER.

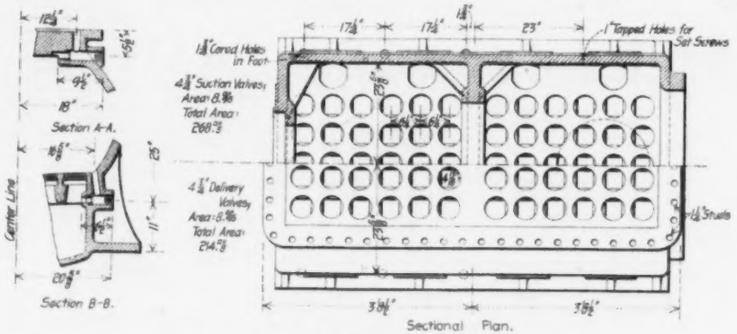


FIG. 2. 23x36 IN. PUMP CYLINDER.

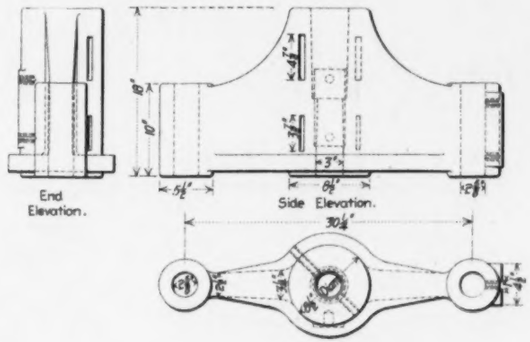


FIG. 16. MAIN CROSS HEAD.

TRIPLE EXPANSION PUMPING ENGINE AT OGDENSBURG, N. Y.

Built by The Snow Steam Pump Works, Buffalo, N. Y.

CHAS. HART, LITH., 28 VESEY ST., N. Y.

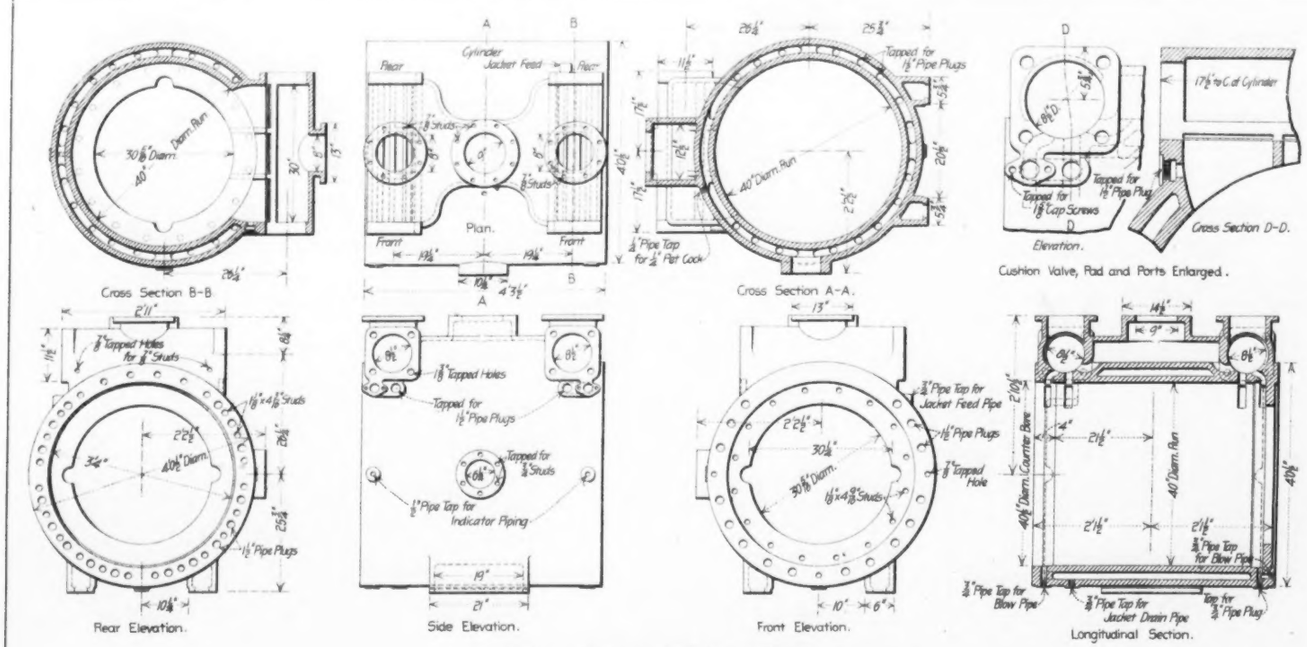


FIG. 7. 40x36 IN. STEAM CYLINDER.

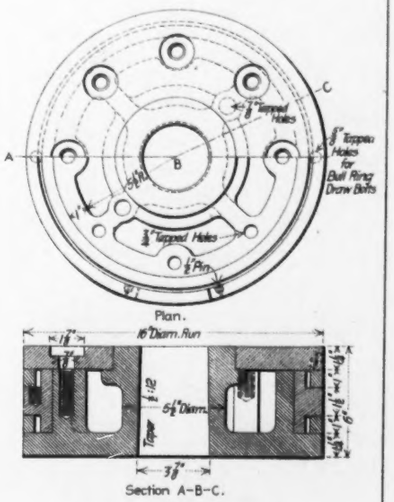


FIG. 8. 16 IN. PISTON.

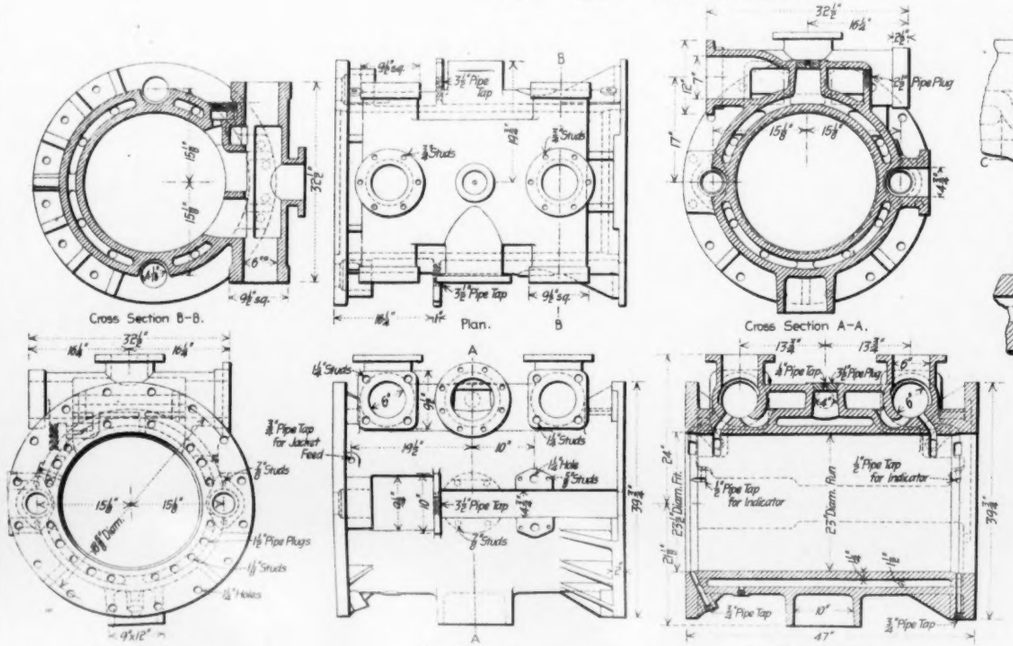


FIG. 6. 23x36 IN. STEAM CYLINDER.

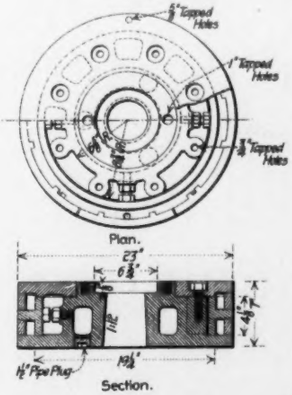
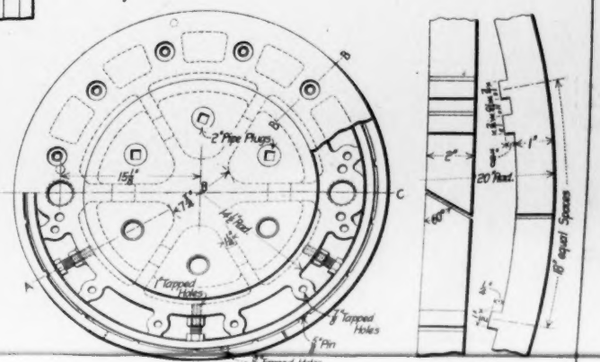


FIG. 9. 23 IN. PISTON.



ent season has carried hardly any wheat, notwithstanding the enormous shipments of this cereal to Atlantic ports; yet wheat was one of its chiefest items of traffic only a few years ago. Over 36 million bushels of wheat were transported on the New York state canals in 1893; but during the present season canal shipments of wheat to New York to Oct. 1 aggregated only 40,000 bushels.

Closely following the announcement of the prospective abandonment of the Delaware & Hudson Canal comes the news that Maryland has decided to dispose of all its interest in the old Chesapeake & Ohio Canal, which has cost the state first and last about $25,000,000. It was offered for sale by the state three years ago; but the only bids received were rejected. The only value of the canal at the present time is as the right of way for a railway line to parallel the Baltimore & Ohio; and it is probable that that company will endeavor to secure it to prevent such an outcome.

The question is often asked why the river and canal transportation routes in this country have been gradually abandoned, while in Europe, notwithstanding the fact that a network of railways covers the country, the traffic on both artificial and natural waterways is steadily maintained. An answer to this question which has been given so often that it has come to be generally believed, is that in the United States the railway companies at an early period secured control of canals for the purpose of wrecking them as transportation routes and getting rid of their competition. There is doubtless a certain amount of truth in this statement, and there was much more truth in it a score of years ago than at the present day. But it is not the real underlying reason for the decadence of water transportation routes in this country. The real reason is that under American commercial conditions freight can be moved at less cost by rail routes than by any system of river or canal transportation. When we say this we speak, of course, in a general way. For such traffic as the transport of coal down the rivers of the Ohio valley, for example, the river transportation, by reason of the peculiar methods by which it is conducted, is cheaper by far than any possible rail transportation. These and similar exceptional instances, however, do not affect the truth of the general statement.

It is of interest to inquire the reasons why rail transportation in this country is so much cheaper and water transportation is so much more expensive than in Europe. First and most important is the larger capacity cars, and more powerful locomotives of American railways, permitting the hauling of heavier train loads. The great volume of traffic and the long hauls make these large cars and long trains possible and economical, as they would not be in a country of smaller area, or one in which the products of different sections are not interchanged on such an enormous scale. Only those intimately familiar with railway matters appreciate the great advancement that has been made in railway practice in the United States during the past two decades. American railway managers have led the world in adapting the railway to the transportation of the cheapest class of bulk freights. Compared with American practice, foreign freight traffic seems like toy railroading.

Another thing which has made possible the cheap movement of freight in this country is the fact that so far as freight traffic is concerned, the railways of the country are operated as a single system. The interchanage of freight cars between different railway companies, enabling a car to travel from one end of the country to the other without transfer of its lading, has saved literally billions of dollars in the cost of handling freight traffic since it was established. Nowhere else in the world is there anything like such a vast system of freight car interchange in operation.

Still another reason why railways have superseded water routes in this country is that all our machinery for the production and distribution of goods is suited to rail rather than to water transport. Most American manufacturing plants of any size have railway sidings and spur tracks running into their yards and often into the buildings themselves, so that raw material is received and finished goods are loaded without any wagon transportation. Comparatively few manufactories except those in seaboard cities or on the Great Lakes are located on a water front.

In the United States the railway has preceded civilization over a large part of its area. The railway and not the river was the original avenue of transportation, and in the building of manufactories, warehouses, etc., everything has been planned with a view to the use of the railway. In Europe things are quite different. European cities with their warehouses were built before the railway era, and convenience to water transportation routes influenced the location of most of them.

The real underlying reason, then, for the abandonment of barge canals in this country is not, as has been so frequently asserted, the political and financial manipulation of the railway companies. The real reason is that bulk freights can under American conditions be carried more cheaply by rail than they can on rivers or canals.

The average railway freight rate per ton-mile for the United States, according to "Poor's Manual," was 1.057 cts. in 1885. In 1897 it had fallen to 0.783 ct. Had the freight shippers of the United States paid the same freight rate per ton in 1897 that they did in 1885, the railways would have increased their profits by more than $268,000,000. This enormous reduction in the charge for carrying freight was made possible by the great increase in the average freight train load. Notwithstanding the fact that the railways received on the average only three-fourths the money for carrying a ton a mile in 1897 that they did in 1885, the average earnings per mile run by freight trains were actually greater in 1897.

We are aware that the past is not a sure guide to future. It is certain that so rapid a reduction in freight rates as has gone on for the past thirty years cannot take place in the future. On the other hand, there is no reason to believe that a final limit has been reached in the cost of transporting bulk freights by rail. Steel cars, and still more powerful locomotives, economies in the methods of loading and unloading cars, and better terminal facilities are some of the means by which further savings will certainly be made.

We do not look for any considerable reduction in the rates on high-class merchandise and "less than carload" shipments. On traffic of this sort the railways are now charging probably less than the total cost of transportation. We do believe, however, that in the handling of bulk freights in great quantities on through shipments, by the use of special rolling stock and, perhaps, of specially-built lines of railway, opportunities exist for the movement of freights by rail at a cost much lower than has yet been deemed possible. Remembering that it is in the coarsest and cheapest class of bulk freights alone that the canal is claimed to be able to compete at all with the railway, it is easy to see that in the near future the old-time barge canal, which is already at the limit of its usefulness, will be left far behind in the competition.

In the light of the plain and well-known facts, which are above enumerated, what would be thought of a company which should propose at the present day to build one of the old-time barge canals as a business venture? Its promoters would be deemed fit candidates for a lunatic asylum. They would be told by financiers that the day of canals is past. That they might as well try to exploit anew the cable system for street railway traction, just when the last of the cable machinery is going to the scrap heap, to be replaced by electric traction, as to propose the building of a new barge canal.

We do not know of any private company which proposes at the present day to build a barge canal; but we do know that the United States government is now actually engaged in constructing such a canal between the Illinois and the Mississippi rivers, in calm disregard of the fact that the day of usefulness for such a waterway has passed. Upon this piece of monumental folly the government has already expended about $2,000,000; and if it carries the work to completion about $8,000,000 to $10,000,000 additional will be thrown away.

It may be of interest to trace the history of this work. During the '70's a large amount of agitation was carried on in the States of Iowa, Illinois, Wisconsin and Minnesota to induce the general government to undertake the building of a canal from the Mississippi River at or near Rock Island, Ill., eastward to the Illinois River, where the existing Illinois & Michigan Canal would continue the waterway to Chicago. Various Boards of Trade and other commercial organizations, both in the West and in the East, adopted resolutions favoring the project; and finally in the early '80's, Congress made a small appropriation for a survey of the route. In the Report of the Chief of Engineers for 1883 we find a record of the survey, together with a statement of the commercial advantages which the new route was to offer. The chief argument for the canal was that it would in effect extend the advantages of the cheap freight rates to and from the East, which Chicago enjoyed to the whole territory covered by the upper Mississippi. A large part of the argument for the canal was based on the idea not that the canal itself would carry the traffic, but that its competition would compel the railways to reduce the rates on the traffic which they carried. As evidence of the need of a reduction in the railway freight rates, a table was given of the average freight rates per ton-mile on several of the leading railways running west from Chicago. We present these figures here, and have added to them the corresponding figures for the same companies for the year 1897, as follows:

Railway.	Average freight rate per ton mile, cts. 1882.	1897.
Ill. Central	1.41	0.67
Chicago & Alton	1.03	0.76
Chicago, Burl. & Quincy	1.19	0.86
Chicago, Rock Island & Pac.	1.22	0.97
Chicago & Northwestern	1.46	1.00
Chicago, Milwaukee & St. P.	1.77	1.01

It will be seen at once that even if it were worth while to build the canal 15 years ago as a lever for reducing freight rates, it does not at all follow that it would be worth while to-day for the same purpose.

Other changes in commercial conditions have greatly altered the aspect of this canal enterprise since it was first projected. At that time Chicago was the outlet for the whole Northwest. The wheat of Iowa and Minnesota and such part of Dakota as was then under cultivation was gathered at St. Paul and Minneapolis and shipped thence to Chicago. The ports at the head of Lake Superior had hardly begun to cut any figure in the grain movement. In 1880 the total receipts of flour and grain at Chicago aggregated 165,855,000 bushels, while Duluth had only 7,617,000 bushels. In 1896, the ports on Lake Superior sent eastward 90,700,000 bushels of grain and 8,800,000 barrels of flour. Thus the whole Northwest, for the supposed benefit of which the Hennepin Canal was originally planned, has now a far better outlet to the east by way of Lake Superior than it could ever have by way of Chicago.

Again, it was supposed by those who originally promoted the Hennepin Canal enterprise that the railways west of the Mississippi would deliver their products to canal barges at the various river towns. It was not foreseen that the railways which collected this grain would prefer to carry it through to the lake port of its destination, and would arrange their freight rates to accomplish this in any event. Neither was it foreseen, though it ought to have been, that it would cost actually less to haul a loaded car from the Mississippi River to Chicago and discharge its lading there than it would to load a little canal barge, tow it over the long stretch of river and canal navigation, handle it in the long chain of locks of the Hennepin and Illinois River canals, and finally deliver its contents to the Chicago elevator. These locks, we may add, are alone sufficient to make traffic through the Hennepin canal absurd as a business proposition.

We need take no more space, however, to prove that this enterprise has long lost the little reason for existence that it once had. The fact is that the public has for years taken no interest in, and has forgotten all about, the Hennepin Canal. Probably nine-tenths of the members of the Chambers of Commerce and Boards of Trade that once adopted strong resolutions in its favor, would now be puzzled to tell where it is. If Congress, in a spasm of wisdom, should decide to drop the whole enterprise where it stands, and refuse to throw good money after bad any longer, we venture to say that no protest would be heard except from the few who hope to profit by the government's expenditure on the work.

Returning now to our general subject of the transfer of traffic from the canals to the railways, it is of interest to note the experience of Canada. The Dominion has expended about $80,000,000 on its canals, and its total revenues therefrom are about $340,000 per annum. The interest on the original outlay, most of which is still represented by bonds, and the cost of maintenance and operation form one of the heaviest items in the government's expenses, and so far as the canals are beneficial, the benefit must be sought in the indirect returns. Some of the canals along the St. Lawrence and the Welland and Sault canals have traffic enough to justify their existence, but the branch canals, such as the Rideau and the Trent, are admitted to be no longer worth the cost of keeping them in repair and operating them. The Trent Canal is still under construction, but appropriations for it are made year after year merely to give the district in which it lies a share of the "pie," not because anyone believes in its commercial value. The Rideau Canal in 1895 cost for maintenance, operation and interest on its cost about $280,000. The total traffic which it carried was 88,700 tons, most of it cordwood and lumber, and the tolls amounted to about $7,000. As for the St. Lawrence canals, they are being enlarged to admit vessels of 14-ft. draft, to accommodate through traffic from the Lakes to the seaboard, and in the hope of diverting a large volume of the traffic which now goes to United States ports. How far they will be successful remains to be seen; but many believe that they will never carry sufficient traffic to justify the millions that have been expended upon them.

In conclusion, it is of interest to note what one of the ablest of American business men, Mr. Andrew Carnegie, has recently said concerning the relative economy of canal and rail transportation. In his speech before the Pittsburg Chamber of Commerce on Nov. 10, Mr. Carnegie spoke of the projected deep waterway from Lake Erie to the Ohio River, as follows:

> Touching the all-important matter of transportation leads me to refer to my connection with the project for making Pittsburg a lake port by water communication. It has been pointed out that I was the first to suggest in a speech to the legislature that the abandoned canal should be replaced by a deeper one which should lead the waters of Lake Erie into the Ohio. Conditions, however, have changed. Such has been the progress of railway development that, if we had a canal to-day from Lake Erie through the Ohio Valley to Beaver, and it was opened free of toll like the Erie Canal, we could not afford to put boats upon it.
>
> I have never concealed my opinion that even if we had a 15-ft. ship canal, the large lake steamers would not come to Pittsburg. It takes a steamer carrying 7,000 tons of ore to live at present rates—within five years, the lake carriers will be of 10,000 tons, and it will be much cheaper to transfer its cargo at the lakes into smaller boats than to attempt to send the monster through the canal. But more than this, it is cheaper to-day to transfer the ore to 50-ton cars and bring it to our works in Pittsburg over our railway than it would be to bring it by canal.
>
> I do not wish to appear even by silence to be considered a party to any attempt to entice private capital to invest in building a canal between Pittsburg and the lakes, because I am convinced that this capital would be entirely lost; if the canal were completed, the existing railroads could and would perform its service cheaper and more satisfactorily, because they can run all the year round.

It should be especially noticed that the proposed Lake Erie & Ohio River Canal, to which Mr. Carnegie refers, was not to be a small barge canal such as we have discussed above, but a waterway of 15 ft. depth, able to carry good-sized steamers and barges. We have ourselves felt that there was at least a chance that such a waterway from Lake Erie to Pittsburg might prove a financial success, although we have seen small prospect of its actual construction. If Mr. Carnegie is correct, however, and the 50-ton freight car is a cheaper carrier than the boats on such a canal, then is it all the more certain that all the old-time small barge canals are doomed to early abandonment, no matter how much money may be expended on them from state or national treasuries.

LETTERS TO THE EDITOR.

The American Railway Engineering and Maintenance-of-Way Association.

Sir: In your issue of Nov. 3, in commenting on the recent preliminary steps taken to organize an association of Engineering and Maintenance-of-Way officials of American railways, I am sorry to note that your criticism was unfavorable to the formation of such an organization. Your main objection appears to be that there are already sufficient numbers of engineering societies to engross the attention of the professional engineer, and that the new society or association is superfluous.

As Secretary of the newly-formed association I have had rare opportunity to note the widespread interest which the mention of this association has enlisted from the purely engineering and maintenance-of-way officials of the American railways. Out of perhaps 400 communications, only about 3% have expressed any opposition to the formation of a Maintenance-of-Way Association.

To the writer it appears that there is as much need for an association to deal with maintenance-of-way matters as there is of a Master Car Builders' and Master Mechanics' Association, which treats of equipment, or an American Railway Association to discuss questions of transportation.

The railways of the United States are properly divided into three sub-operating departments, which are Maintenance-of-Way, Maintenance of Equipment, and Conducting Transportation. Taking into consideration the general expenses, the proportion of expense in operations of the railways is about as follows:

Maintenance-of-Way	19.5%
Maintenance of Equipment	15.5%
Conducting Transportation	54.0%
General	11.0%
Total	100.0%

The expenditure of the 19.5%, or a sum equal to $150,000,000 to $200,000,000 annually in the Maintenance-of-Way department of railways deserves as much consideration at the hands of the officials in charge of such departments as the $100,000,000 to $125,000,000 expended in the Maintenance of Equipment Department but as a matter of fact, the latter department gives more attention to uniformity of methods and aims more to a united or uniform system for the entire railway mileage of the country than the Maintenance-of-Way department. It is true that this is largely due to the necessity of interchange which prevails in the Rolling Stock department, and which does not apply to the other departments; but it cannot be successfully contradicted that a Maintenance-of-Way Association, embodying in its organization the best talent in its particular line, would result in a vast amount of good to American railways. It is this cause that has brought the Maintenance of Equipment department to its present high state of development and efficiency.

The matter of supreme importance is to organize the Maintenance-of-Way Association along proper lines. Many favor the membership to be by railway companies, or an organization similar to the American Railway Association and the Master Car Builders' Association. Others, and by far the larger number, favor an individual membership restricted to railway engineers and maintenance-of-way officials above a prescribed grade, excluding all engineers from eligibility who are not directly connected with railway maintenance-of-way work. For they contend that it is to be a specialty, having for its aim the advancement of the theory and practice of railway engineering and maintenance-of-way work, which is a field broad enough in its extent to merit the sole attention of the association. Those contending for company membership hold that the results of the association would be adopted by the various railways more readily than if such results were the opinions of an association of individuals as members—in short, the benefit to accrue to the railways would be to the maintenance-of-way department what the American Railway Association is to the transportation department.

It is apparent, therefore, that the future of the organization depends upon its being launched on proper lines, and the subject is of such vital importance to the railways that it should receive the serious thought not only of the maintenance-of-way officials, but of all officers having charge of railway operation, and a full attendance at the meeting in Buffalo, in March, 1899, is desirable. Respectfully,

L. C. Fritch,
Secretary American Railway Engineering and Maintenance-of-Way Association.
Washington, Ind., Nov. 15, 1898.

Notes of an Engineer in Colorado.

Sir: The railroads entering Leadville present a fine opportunity for a study of the different types of mountain roads, and for a comparison of the merits of direct alinement and heavy grades vs. longer lines and easy grades. The Denver, Leadville & Gunnison and the Colorado Midland roads are fair samples of the first type, and the Denver & Rio Grande standard gage of the second.

The D., L. & G. (narrow gage) has an 11,500 elevation at Boreas and one nearly as high at Fremont Pass, and has much 4% grade and a heavy snow-fall in the winter to battle with. Formerly Leadville was reached by a branch from Buena Vista, 35 miles south of Leadville. Though this line was 28 miles longer (179 miles) than the present one, it had but one 10,000 ft. elevation, no snow to bother and only 2% grades. The road has never paid since the branching off point was changed from Buena Vista to Como. This road continues from Buena Vista on southwest to Gunnison, climbing up to the Alpine tunnel through the Continental Divide at an elevation of 11,623 ft.

The Colorado Midland is the most notable example of broad gage roads belonging to the first type that can be found. The main line from Colorado Springs to New Castle is 234 miles long and cost between $19,000,000 and $20,000,000. The greater part cost about $100,000 per mile, and the line is said to have been the most expensive to construct of any in the world. The country is very difficult. The maximum grade is 4%, reaching from Manitou Iron Springs to Cascade Canyon, and it is equated on curves at the rate of 0.06 ft. per 100 ft. The maximum curvature is 16°. For the remainder of the line the maximum grade is 3%, including that over the Continental Divide. The distance from Colorado Springs to Leadville is 135 miles. (From New Castle to Rifle—13.4 miles—the Colorado Midland uses the track of the Denver & Rio Grande, and from there to Grand Junction—62 miles—they both run over the Rio Grande Junction Ry.). The Midland has a total trackage of its own of 357 miles, including several branches.

About 17 miles west of Leadville the line crosses the Continental Divide. As first built, the road pierced the divide with the Hagerman tunnel, but afterwards the Busk-Ivanhoe tunnel was built. (Eng. News, Jan. 17, 1891, and Aug. 25, 1892.) The Hagerman tunnel is 2,081 ft. long, and is at an elevation of 11,528 ft. The high line running through here was very expensive to operate, so that in July, 1890, work was begun on the Busk tunnel, the first trains running through in December, 1893.

It was estimated that there would be a saving of maintenance charges of $70,000 per year by doing away with the surface line. There were 13 snow-sheds, aggregating a mile in length, and 12 bridges and trestles—one of them 1,200 ft. long and 84 ft. high. Besides the maintenance charges there were the delays by snow and the loss of patronage due to the same; by the new line there was also the saving of 7 miles in distance, 580 ft. in elevation and about 2,000° in curvature to go to lightening the operating expenses. So when it was calculated that the tunnel could be built for $1,000,000, the railway company readily guaranteed the 7% on the cost of construction to the Busk Tunnel Ry. Co. The cost, however, was $1,250,000, and the Colorado Midland Ry. Co. contracted to pay 25 cts. for each passenger and each ton of freight hauled through the tunnel.

The railway company went into the hands of a receiver about 1894, but was reorganized the latter part of last year. The receiver, Mr. Geo. W. Ristine, was elected president and general manager, and at once went to work to try to break the contract in the courts. An offer was made to pay 3%, and then 4%, in place of 7%. The parties seem to now be in a fair way to agree. The Colorado Midland has been running trains over the old route, over the summit, for a year or two past. Most of the track had been torn up, and this had to be replaced and the trestles and snow-sheds put into shape before using.

The west portal of the Busk tunnel has an elevation of 10,945 ft., while the summit overhead the tunnel is about 12,000 ft. The tunnel cross-section is 15 ft. wide by 21 ft. high, while that of the older Hagerman tunnel is 15 × 19 ft. The maximum grade on both sides of the divide is 3%.

Turning now to the Denver & Rio Grande road, we find that it has followed the main drainage channels of the country as far as possible, thus securing water grades for its lines. While this has usually lengthened the general route, the avoidance of sharp curves and heavy grades has more than compensated for it. Thus from Colorado Springs to Leadville by the Colorado Midland is 138 miles, and it is only 157 miles from Pueblo by the Denver & Rio Grande, though Pueblo is 45 miles south of Colorado Springs and the general route is much longer. Again, from Leadville to Glenwood by each line is about 90 miles. The general route by the Denver & Rio Grande is longer. The maximum grade for west-bound trains on the Denver & Rio Grande is 1.42%, and 3% for the Colorado Midland, being 3% on the west slope for both roads. The maximum curvature on both sides of the divide on the Colorado Midland is 16°; on the Denver & Rio Grande it is 10° on the east side and 12° on the west side.

The operating expenses, due to much easier grades, lighter curves and less snow, and also the maintenance charges due to much less trestling to keep up, show very much in favor of the Denver & Rio Grande. This road has 10° maximum curves (except one of 12° in the Royal Gorge) and 1.42% maximum grades (compensated) for its three-rail line from Denver to Pueblo and on to Leadville. Leadville is not on the main line, and only passenger trains run through it. West-bound trains leave the main line at Malta for Leadville, and in the 5 miles there is a rise of 620 ft., with a maximum grade of 3%, requiring a helper engine. Continuing on west, the main line is reached at Leadville Junction.

Leadville.—Leadville has been a noted mining camp since 1876, when the silver and lead carbonates which gave it its present name were discovered. The original camp of California Gulch produced nearly $5,000,000 in gold from the placers between 1859 and 1862, after which it was nearly abandoned. Between 1876 and 1896 the Leadville district is said to have produced precious metals to the value of $206,000,000. Among the mines which have given celebrity to the town are the Little Pittsburg, which went far toward making the fortunes of several of the wealthiest men in Colorado; the Robert

E. Lee, which yielded $118,000 in a single day; the Maid of Erin, Little Johnnie and many others. The carbonate deposits, of which the city is the center, are said to cover an area of 60 miles in length north and south by 10 miles in width. Over 30,000 mining locations have been made near the city, but the production has all come from about 50 mines. Since the slump in silver, Leadville, of course, has suffered severely; and from June, 1896, to March, 1897, a great strike of the miners was on that paralyzed the industrial interests of the town for the time and threatens to have left permanent bad effects.

Many of the largest mines here lie in the "Leadville Basin," being known as "down town mines" in distinction from those on the high mountains east of town. In all these mines, no sooner do the shafts reach the level of the ore bodies than enormous bodies of water are encountered. These have for years been pumped out at a cost of thousands of dollars per month. During the strike the operation of pumping this water out got to be decidedly monotonous, so the owners of some of the larger mines pulled their pumps, when the mines soon filled up. Others followed suit, so that at the present time there is but one small property in the entire area operating, which ships about 25 tons of iron ore per day to Pueblo.

The Leadville Pumping Association has been formed, composed of the owners and lessees of all the ground in this basin, for the purpose of pumping out the water and keeping it drained for a period of eight years, the expense to be divided equitably. Sufficient machinery has been bought, and $80,000 has been subscribed by the members and the merchants of the town for prosecuting work. It is figured that it will take fully three months to drain the workings now, and then then over a month to retimber and clean the shafts and drifts. As the state was put to an expense of about $300,000 in maintaining order during the labor troubles, it has been a very expensive strike all around.

Of late years manganese iron ores have come to be an important part of the product. One mine ships from 100 to 200 tons per day to the Illinois Steel Works, and also ships heavily to the Bessemer Steel Works at Pueblo.

Since 1893 much attention has been paid to prospecting gold properties in this region, with the result that extensive bodies of gold ore have been discovered. The center of the gold bearing territory is Breece Hill, north of California Gulch. The Little Johnnie mine here is said to be the greatest gold mine in the country to-day.

I took a trip into the Yak tunnel, that is being bored into Breece Hill for the purpose of tapping the rich ore bodies and to serve for transportation and drainage for the different mines passed through. The tunnel is now in 7,000 ft., and has only lately pierced the Breece Hill region. It will strike the tunnel company's property, located on the top of Breece Hill, at a depth of 1,275 ft. It is to be extended for 7,000 ft. further, or 14,000 ft. in all. All water encountered is drained or pumped into the tunnel to be drawn out through the mouth in California Gulch. Near the mouth of the tunnel is the air compressor plant, which is operated by water power obtained from a supply main for the city water-works that passes by here. The 335 ft. head produces about 85 HP. when water is plentiful, and the discharge water is returned to the main to pass on down to the city.

The total output of ore of all kinds at Leadville has lately averaged about 1,800 tons per day. The Arkansas Valley Smelting Co.'s smelter is one of the largest in the West, and that of the Union Smelting Co. is also quite large. These work up much of the ore that would not pay to ship.

The Leadville water-works are owned by a private company. Mr. C. N. Priddy is superintendent. Owing to the high altitude there is much difficulty in keeping the system in operation during the winter. Until 1895 the east fork of the Arkansas River (the only considerable stream of this locality) was tapped by an open ditch, called the Oro ditch. Then the water company laid a 36-in. wooden pipe line in this ditch. The pipe draws water from the river and is 33,000 ft. long. It follows the ditch all the way except for one cut through a ridge and one inverted siphon across a gulch, called Evans Gulch. The former shortens the line from 6,130 ft. to 1,570 ft. The latter is 900 ft. long and sustains a static head of 100 ft. at the bottom and a hydraulic head of 46 ft. The hydraulic grade line falls 11 ft. to the mile. The banding varies from 75 ft. per 100 ft. at the head to 225 at the end (where the static head is 66 ft.), and 375 at the bottom of the siphon. The pipe line discharges into a reservoir near Stray Horse Gulch, that runs through the north part of town. The pipe was built of Louisiana pine staves. Mr. Thos. W. Jaycox, M. Am. Soc. C. E., of Leadville, was the engineer.

There is a 50 million gallon reservoir on Big Evans Gulch and a 25 million one on Empire Gulch. These and the Iowa Gulch—all from the range east of town—are the additional sources of supply.

In the operation of the distribution system much ingenuity is displayed in the keeping of the pipes clear of ice. All service pipes are enclosed in a double wood box, with air space between. Steam hose is let down the stop box and the pipe thawed out when frozen. The service pipes are lead or galvanized iron, extra thick. A steam engine for thawing out mains and hydrants is in constant use during the winter. The hydrants are tested every day. They are double-case, and when frozen the barrel or inside part is pulled out and steam is forced onto the ice at the bottom. When the mains freeze, a hole is bored down into the pipe where needed and the steam hose inserted. The nozzle of this has one jet in front and four behind, the reaction of the ones behind forcing the hose along through the ice as fast as melted large enough, and the rear jets also melt the surrounding ice left behind as it travels. The hose is extra thick, to avoid cooling too fast. All pipe is buried 6 to 7 ft. deep, but this does not prevent freezing.

The headwaters of the Arkansas (near Tennessee Pass) often freeze up, thus cutting off the supply from that source for months at a time. During the last winter, from the beginning of November to the end of February, only once or twice did the temperature at the headwaters reach as high as the freezing point. January, February and March are usually the low water months.

The distribution system has 156 Holly single and double nozzle 6-in. hydrants, with 4-in. connections to street mains. Nearly all mains are not less than 6-in.

Glenwood Springs and Aspen.—Resuming the journey west from Leadville over the Denver & Rio Grande, the Tennessee Pass tunnel is reached at 6 miles. The old narrow gage grade that passed over the summit is plainly visible for a long ways each side of the tunnel. This is the summit of the Continental Divide, the drainage running on the east to the Atlantic and on the west to the Pacific. The tunnel is about a half mile long, and is timbered. On leaving the west or north end a descending grade is begun that reaches to Minturn, 25 miles. The average fall is over 100 ft. per mile, with a maximum of 3%. The road does not rejoin the old narrow-gage route until several miles from the tunnel, the latter having much more development and lighter grades. It then enters the valley of the Eagle River. At 10 miles, Pando tunnel—cut through solid granite—is reached. Below this is an interesting piece of railway construction, where the Eagle River is diverted through a cut across a ridge that separates it from another valley. This leaves room for the railway to occupy the entire bottom of the river valley until the side valley joins it about a half mile down. The diversion is quite inexpensive. It was made for the purpose of retaining the ruling gradient of the road, which made it necessary to cut below the natural channel of the river in the valley.

There is much attractive scenery all the way, and passing Red Cliff—a noted mining town—the Eagle River Canyon is entered. This extends to Minturn—8 miles—and is grandly picturesque. Miners' cabins can be seen at the mouths of tunnels and drifts hundreds of feet above the track. The town of Gilman, which is simply a collection of cabins, reminding one of the cliff-dwellers, is said to be 1,000 ft. above the bed of the canyon.

About 20 miles above Glenwood the canyon of the Grand River is entered. This is a peculiar and picturesque canyon, the rocks being of volcanic origin. Just below the mouth of this, Glenwood Springs is reached. I stopped over here for two nights, taking a run up to Aspen and return in the day time. Glenwood is justly noted for her splendid health-restoring springs and balmy climate. On account of its being in a park protected by mountains on all sides, the winter climate is quite mild, and it is said that many invalids live in tents the entire season. Nearly all tourists who journey this way stop over, so that the resort receives much free advertising. A long double-decked bridge crosses the river and railway track here, connecting the town proper on the south side with the springs and park and the great Colorado Hotel on the north side. The whole place is well lighted by electricity at night.

Glenwood Springs is thought to be the first place in Colorado to have a lighting plant operated by water power. The plant was installed more than ten years ago, and has been in constant and successful operation since. The station is on the north bank of the river, just between the vapor cave and the big spring, and the freedom from dust and smoke are quite befitting qualities with such beautiful surroundings. The water supply is taken from "No-name" Creek, at a point 3 or 4 miles distant, giving a head of 380 ft. There are four 36-in. Pelton wheels, operated by single deflecting nozzles, using hand regulation. Each wheel develops 125 HP. at 500 revolutions per minute. There are two 25-K-W. Brush direct-current and one 30-K-W. Brush incandescent lighting machines; also one 30-K-W. Brush alternator and one 60-K-W. Westinghouse alternating arc light generators. 3,000 incandescent lamps and 65 arc lamps are supplied. The lighting machines are belted to the water wheels at 3 or 4 to 1, and the speed of the latter is varied to suit the current desired. The water supply of Glenwood is also furnished by the same company and from the same source.

The distance from Glenwood to Aspen by the Denver & Rio Grande is 41 miles. The railroad runs southeasterly and follows up the Roaring Fork River all the way, traversing a pleasant valley with considerable farming and truck gardening.

Aspen is west of and only 28 miles from Leadville in a direct line, though by the route we have come it is 131 miles. The Aspen Silver mining camp is second only to that of Leadville. The town is situated at the foot of the slope of Aspen Mountain, near the junction of Hunter's, Castle and Maroon creeks with the river. The elevation is 7,775 ft.

The hills surrounding the town are rich with veins of silver, some of which reaches to $1,800 per ton. The Mollie Gibson is said to have been the richest mine in the world, while the Smuggler, Emma, Aspen and others are quite noted.

The Mollie Gibson has paid over $4,000,000 in dividends. The choicest bodies of ore have evidently been worked out, as no dividends have been paid since Jan. 1, 1895. Some of the veins in this mine have been almost pure silver.

Aspen has sadly felt the effect of the fall in silver. The annual production was formerly $8,000,000 to $10,000,000 per year, but in 1897 it was only $3,000,000, or about one-fourth that of the state.

The tributary creeks of the Roaring Fork River afford fine opportunities for the production of water power, which have been fully utilized. The electric lighting of the town and the suply of light and power to many of the mines and mills has been made possible at a very reasonable cost, whereas the use of coal would be quite expensive. There are two companies here producing and supplying electric light and power on a large scale.

I. Roaring Fork Electric Light & Power Co.—This company has two plants, one on Hunter's Creek and one on Castle Creek. The former plant was put in operation in 1889, and was one of the first attempts to operate the machinery in mines and mills by electrical transmission on a scale of any magnitude. Hunter's Creek comes into the river from the east and the power plant is located on the river at the east end of town. Water is diverted from the creek through a covered flume to the face of a mountain overlooking the city, where it is discharged into a wooden tank. From here a steel pipe line 18 to 14 ins. diameter and over a half mile long leads directly down to the power house. The fall is 900 ft., and the working pressure used is about 365 lbs.

The power is developed by eight Pelton water-wheels, 24 ins. diameter, which run at 1,000 revolutions and have a maximum capacity of 175 HP. each. Only six of these are at present in use. The light plant consists of three 30-K-W. Brush arc dynamos, two 100-K-W. Brush incandescent dynamos and three 60-K-W. Westinghouse alternators. There were formerly two Edison power generators, but the use of these and the arc light machines has been discontinued, and only incandescent lighting is done from this station now. When the water supply here is low, a current of electricity is brought over from the company's Castle Creek station, supplying an Edison motor, and thus supplementing the power required. A steam plant for a reserve in case of emergencies is also in place here, but it has not been called on for five of six years. A voltage of 110 is used at the direct current machines, while 1,000 volts are used at the alternating current machines, and this is stepped down to 50 volts at suitable places for lighting. The entire town and many mines and mills are lighted from this station.

The Castle Creek station of this company is located on Castle Creek, at the west end of town. The waters of both Maroon and Castle creeks are utilized. The plant was erected in 1893. Castle Creek is the largest of the creeks, but the water has to be divided with other users. So part of the supply is taken from Maroon Creek, giving a head of 312 ft. The supply from Castle Creek is under a head of 330 ft. This head is obtained within a distance of about a mile, the water being conveyed in a covered flume for part of the way, from the end of which a 24-in. pipe leads down to the station.

The five Pelton wheels are all on one shaft running the length of the building. These are about 5 ft. in diameter, but vary slightly to give the same speed with the two different heads. About 250 HP. is developed at each wheel. The wheels are provided with friction clutch couplings for operating independently. The speed is 300 revolutions per minute.

There are five 200-K-W. Brush generators driven direct from the main shaft by friction clutch pulleys. The power house is about 50 × 100 ft., giving plenty of room for a convenient arrangement of machinery. This plant distributes power to a number of mines within a radius of 5 miles. The general manager of the company is Mr. C. E. Doolittle, who has made some notable improvements in speed governors for water-wheels.

II. People's Electric Light & Power Co.—The plant of this company is located on Castle Creek, over a mile above the one last mentioned. Water is supplied through a box flume 2½ × 5½ ft. and 2 miles long. This has a fall of 8 ins. per 100 ft. It discharges into a penstock, from which the pressure pipe leads down to the station. This pipe is 3 ft. in diameter at the head and 2 ft. at the foot, and gives a static head of 190 ft. and a working pressure of 80 lbs. The power house has two rooms, the north one containing the machinery for producing power and the south one that for producing light. There are two 5-ft. double 4-in. nozzle Pelton wheels of 300-HP. capacity each, running at 230 revolutions and driving four 100-K-W. Edison generators at 666 revolutions.

For lighting there are two 3-ft. double-nozzle Pelton wheels of 75 HP. each, driving a 60-K-W. Thompson-Houston alternator and a 25-K-W. Thompson-Houston arc light machine. The former is a 1,100 volt, 1,100 light ma-

chine, the voltage being reduced to 52 by transformers at certain points. The arc dynamo supplies 50 lights.

Closely allied with the electric company is the Castle Creek Tunnel & Power Co. This company is engaged in driving the Newman tunnel for mining development, the mouth of which is quite near the electric station. Power and light for the prosecution of the work are furnished from the station. A 9-ft. Pelton wheel drives a Norwalk Iron Works air compressor, with cylinders 22 and 16 × 24 ins. They are direct-connected, and the speed varies from 45 or 50 to 80 or 90 revolutions, the capacity being 125 HP. The compressor supplies air to the drills at the face of the tunnel. A small 110-volt machine also supplies light to the tunnel. The face is now about a half mile in. Mr. Geo. S. Newman is president and manager of both companies.

The water supply of Aspen is furnished by the Castle Creek Water Co., taking water from both Castle and Hunter's creeks. The supply is, of course, all gravity. A pressure of 100 lbs. is obtained from the former creek, and from the latter (the supply of which runs short during low water on account of being used by other powers) it is 125 lbs.

While in Aspen I took a trip into the great tunnel being driven by the Cowenhoven Mine Tunnel & Drainage Co. This tunnel taps a number of mines on its way, besides serving to drain the ground overhead. The parties working the different mines pay so much per car to the tunnel company for hauling their ore out. The minimum charge is $1.25 for low grade ore, and it increases rapidly with the grade or value of the ore. Waste rock is hauled for 75 cts. per car. The cars holds about 3,000 lbs. and 10 are hauled in one train.

The tramway is double-tracked, and rigid rules are enforced regarding the use of it and of the tunnel by the workers in the mines and others. Wherever connection is made with a mine a side track is put in, and the ore is slid down through a chute or brought into the cars on a level, as the case may be. The tunnel is now in nearly 2½ miles. An average of 9 to 11 ft. is driven per day of three shifts. The best record was made last May, when 428 ft. was driven.

Compressed air is supplied to the two air drills at the front by an air compressor plant at the mouth, and incandescent lighting for the tunnel is also supplied. Through all earth and insecure rock the tunnel is timbered with 10 × 10-in. posts and caps. The tunnel falls towards the mouth about 6 ins. per 100 ft., and a box drain between the tracks carries the water drained from the mines. This tunnel when completed will have a length of over 5 miles, and will open into a different valley on the opposite side of the range, whence it is intended to build a railway to a more direct connection with the Denver & Rio Grande main line. W. P. H.

Salt Lake City, Utah, Sept. 1, 1898.

Notes and Queries.

"Common Logarithm," Washington, D. C., will receive a reply to his letter if he sends us his name and address.

F. A. L., Carlyle, Ill., wants the address of a maker of small water motors, which will run steadily under pressures varying from 20 lbs. to 80 lbs. per sq. in., and drive generators for electric lighting.

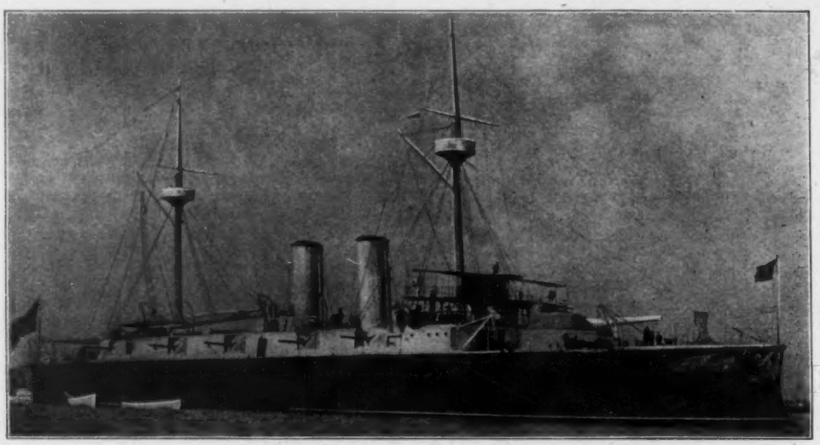
A correspondent writing from Barnet, England, states that the brief description of the railway accident given on page 241 of our issue of Oct. 20 is incorrect. He states that the accident occurred at Wrawby Junction, near Brigg, some 200 miles from London, and resulted from some timber projecting from a freight train standing on a parallel track.

We have received a letter from Mr. C. F. Petersen, regarding the several formulas for determining the volume enclosed between two intersecting cylinders, published in our issue of Oct. 6. He also replies to the criticism of his formula made by Mr. Thomas in a discussion of these formulas published in the issue of Nov. 10. Mr. Petersen in the original solution which he sent us gave several formulas of different form, and in the communication just mentioned he states that the one selected and printed as his solution of the problem was not the proper one. The letter is too long to publish in full, so we give only the final formula, which he says is correct to within 1 in the third decimal place, and compares very closely with those suggested by Messrs. Baldwin, Comstock, Talbot, Dean and Thomas. The formula is:

$$\text{Volume} = \frac{a^4}{r}\left\{0.393 + \left[\frac{a}{r}\right]^3 0.082\right\}.$$

We regret that the limits of our space and the press of other matters will not permit further presentation of this subject, and we must, therefore, close the discussion with this note.

In connection with the discussion on the relative corrosion of steel and wrought iron, raised by the query of R. S. W. in our issue of Oct. 8, 1898, Mr. Alfred M. Mosscrop, Assoc. M. Am. Soc. C. E., refers the parties to an article in Engineering News, of Nov. 15, 1894, as one of the most complete on this subject. It is an abstract of a paper presented to the Institution of Civil Engineers by Mr. Thomas Andrews, on "The Effect of Stress on the Corrosion of Metals." Mr. Andrews concludes that when wrought iron and various steels are exposed to the action of sea water for a long time, and without liability to other than local galvanic action, the steel showed the greatest corrosion, the wrought iron having an advantage of about 25% in this respect. The corrosion also increased in the steel as the percentage of combined carbon was greater. He also found that galvanic action between wrought iron and steel largely increased the total corrosion in both metals. He also says that stress considerably affects the corrosion, and "unstrained" metal, being softer, is the most liable to corrosion. But the experiments also indicate that the action of local galvanic currents between strained and unstrained parts of a forging, bar, or plate, tends to increase the corrosive action.



The ARMORED CRUISER "INFANTA MARIA TERESA."
Built at Bilbao, Spain, 1893, by La Sociedad Anonima de Los Astelleros del Nervion. Captured in the Battle of Santiago, July 3, 1898. Wrecked on Cat Island, Bahamas, Nov. 5, 1898.

THE CAPTURED SPANISH CRUISER "MARIA TERESA."

We show herewith an excellent half-tone view of the cruiser "Maria Teresa," whose unfortunate loss while on her way to the United States we have already recorded. The engraving, which we have reproduced from the "Zeitschrift des Vereines Deutscher Ingenieure," of March 27, 1897, shows the vessel as she appeared when in commission in the Spanish Navy. Her dimensions and general particulars have been so frequently published that we do not repeat them here, further than to note that the armor and armament of the vessel really entitled her to rank as a second-class battleship, and her speed of 20.24 knots attained in a four hours' contract trial in September, 1893, placed her in the front rank in the class of armored cruisers.

COMPOUND CONSOLIDATION PUSHER ENGINE; LEHIGH VALLEY R. R.

On many railways the profile is such that heavy train loads can be economically hauled over the greater part of the line, but at certain points there are steep grades which would limit the ordinary train load or make it necessary for the trains to be divided at the foot of the grade and taken up in sections. In order to ensure the economy due to the transportation of large train loads, and to avoid delays incident to splitting the trains, powerful pusher engines are frequently employed to help the trains up these grades, and we illustrate this week a large engine of this type recently built for the Lehigh Valley R. R. by the Baldwin Locomotive Works, of Philadelphia, Pa.

It is to run from Coxton to Fairview, 27 miles, without taking water. Its guaranteed hauling capacity is for 1,000 tons of train load behind the tender, at an average speed of 17 miles per hour, on the mountain cut-off.

The engine is of the consolidation type, on the Vauclain four-cylinder compound system, with balanced piston valves. It is fitted with the Wooten firebox for hard coal, the cab being placed at the junction of the boiler barrel and firebox. The dome (with whistle at the side) and sandbox (with air jet device) are mounted on the boiler barrel, while the bell and safety valves are mounted over the firebox. A footboard extends from the cab to the boiler head, and the fireman on the tender deck is sheltered somewhat by a canopy. The crosshead and slides are protected by a casing. The tender is of large size, and is mounted on a pair of Fox pressed steel trucks. The engine is shown in the accompanying cut, and its leading dimensions and particulars are as follows:

COMPOUND CONSOLIDATION PUSHER ENGINE; LEHIGH VALLEY R. R.
S. Higgins, Superintendent of Motive Power. Baldwin Locomotive Works, Builders.

Compound Consolidated Pusher Engine; Lehigh Valley R.R.

Running Gear:	
Driving wheels (8), diameter	4 ft. 7 ins.
Truck wheels (2), diameter	3 " 0 "
Tender wheels (8), diameter	2 " 9 "
Driving wheels centers	4 " 1 "
Journals, driving axles, 9 × 12; Truck axles	6 × 12 "
Journals, tender axles	5 × 9 "
Wheelbase—Driving	15 ft. 0 "
Total engine	23 " 10 "
Engine and tender	55 " 0½"
Weight in Working Order (without fire or men):	
On driving wheels	202,232 lbs.
On truck wheels	22,850 "
Engine, total	225,082 "
Tender, empty...45,250 lbs.; loaded	120,918 "
Engine and tender	346,000 "
Cylinders: Number	Four.
Diam. and stroke of h. p., 18 × 30 ins.; l. p.	30 × 30 ins.
Valve gear: Type	Link motion.
Slide, valves, style	Balanced piston.

Boiler: Type	Straight top.
Diameter, barrel, inside smallest ring	6 ft. 8 ins.
Thickness, barrel plates, ⅝ in.; smokebox tube plate ½ in.	
Working steam pressure	200 lbs.
Firebox: Type	Wootten.
Length, inside	10 ft.; width, inside 9 ft.
Depth, at front, 5 ft. 2⅝ ins.; depth at back, 5 ft. ⅝ in.	
Thickness, side and back plates	⅜ in.
Thickness, crown plate, ½ in.; tube plate	⅝ in.

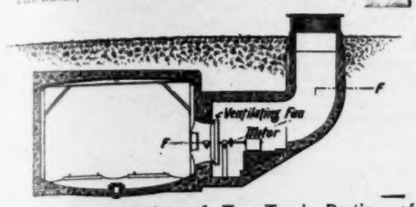
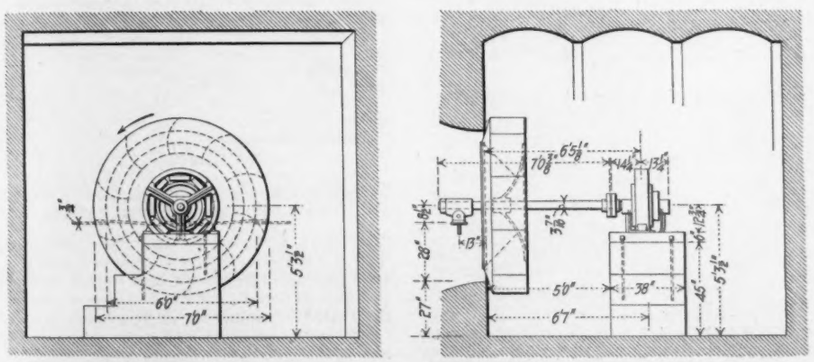


Fig. 1.—Cross-Section of Two-Track Portion of Boston Subway, Showing Ventilating Chamber.

Tubes: Number	511
Diameter, outside	2 ins.
Length over tube plates	14 ft. 7¾ "
Heating Surface and Grate Area:	
Heating surface, tubes (interior area)	3,890.6 sq. ft.
" firebox	215.0 "
" total	4,105.6 "
Grate area	90.0 "
Miscellaneous:	
Limit of width	10 ft. 3 ins.
Limit of height	15 " 4 "
Capacity of tender tank	7,000 gallons.

VENTILATION OF THE BOSTON SUBWAY.

We illustrate herewith the method used for ventilating the Boston Subway. The sectional view, Fig. 1, reproduced from the first report of the Boston Transit Commission, 1895, indicates the general arrangement adopted for the two-track portion of the subway. For the four-track portion the fan chamber is larger, containing two fans, and discharging into a stack 11 ft. 6 ins. diameter. The other cuts, showing one of the fans and its attached motor, have been made from drawings furnished by the B. F. Sturtevant Co., Boston, Mass., to whom we are also indebted for the following description:



End Elevation. Side Elevation.

FIG. 2.—7-FT. VENTILATING FAN, WITH ELECTRIC MOTOR USED IN THE BOSTON SUBWAY.

Designed and Built by B. F. Sturtevant Co., Boston.

In the past the ventilation of railroad tunnels or subways has had for its principal object the removal of smoke and gas discharged by the locomotives employed for traction purposes. But with the advent of electric power and its wide application to street car propulsion, the most important objection to underground transportation has been removed.

Nevertheless, there still remains, as has been clearly demonstrated in the Boston subway, the necessity of a positive and continuous change of air for the double purpose of maintaining its purity and of so regulating its humidity as to prevent the deposition of moisture and the chilling of passengers and employees. This latter feature is of the utmost importance, as is readily shown by the fact that the dew-point of air of 90° F., having a relative humidity of 70%, is about 79° F. That is, if with an external temperature of 90°, there be but a slow and uncertain movement of the air within the subway, it may be readily cooled through 10° or more, thereby become saturated, and not only cause great inconvenience by the constant dripping from all structural work, but become a positive menace to health. A rapid change of air, such as may be secured by mechanical means, serves to equalize the internal and external temperatures, and to prevent the maintenance of a humid atmosphere. At the present time periodical readings of temperature and humidity are being taken under the direction of the Transit Commission, and the results will undoubtedly appear in their forthcoming report.

The original designs of the Boston Transit Commission contemplated the introduction of electrically-driven fans at suitable points along the route. Four of these have already been constructed and installed by the B. F. Sturtevant Co., of Boston, two near West St., and two between Hollis and Eliot Sts. The former location is practically midway between the Boston and Park St. entrances, at each of which there is ample opportunity for the free ingress of air. The space coming under the control of the fans at this point is about 1,050,000 cu. ft. The Hollis and Eliot St. section contains about 900,000 cu. ft.

The fans were, in each case, designed to have a capacity equivalent to an air change in each section once in about 15 minutes. The drawing shows one of the fans at the Hollis and Eliot St. chamber.

The fans are all of the Sturtevant cone type, each consisting of a cast iron conoidal center, with annular back plate of steel attached thereto, and a series of reverse curved steel plate blades or floats, tapering from inlet to periphery, attached to the annular back plate and to the front plate containing the inlet opening. In its course through the fan the direction of the air is gradually changed from axial to radial, the curvature of the blades being such as to offer the least resistance to the passage of the air and to secure the highest efficiency.

The two fans between Hollis and Eliot Sts. are each 7 ft. in diameter, and were designed to each deliver 30,000 cu. ft. of air per minute, when operated at 175 revolutions per minute, and to require an expenditure of about 7 HP. each for their operation under ordinary atmospheric conditions. At one-half the speed the power expenditure would be about 1 HP. Both of these values will naturally vary with the density of the air and the existing temperatures within and without the subway. The two fans near West St. are both 8 ft. in diameter, each designed to deliver 37,000 cu. ft. of air per minute, at 170 revolutions, with a power expenditure of about 10 HP., and to require 1.25 HP. when driven at half speed.

Each fan is provided with an electric motor of special Sturtevant M. P. 8 type, direct-connected to the fan shaft by an insulated coupling. The armatures are of the drum type, thoroughly ventilated and rendered moisture-proof by being saturated in japan and thoroughly baked after having been effectually insulated with mica and oil-cloth. They are shunt wound for maximum speed at 550 volts and arranged for series or a parallel operation, having a starting and regulting resistance giving different speeds for each combination. The maximum temperature rise for 10 hours continuous operation is limited to 45° for the armature, and to 50° for the commutator or fields.

Each motor is mounted on a substantial insulating base frame, constructed of Georgia pine, thoroughly filled to prevent absorption of moisture, and anchor bolted to the concrete foundation.

AN IMPROVEMENT IN RAIL JOINTS.

One of the rail joints of the bridge or base-plate type, which was somewhat extensively used at one time, was the Heath joint, which consisted of one bar forming a base-plate and angle bar and one plain splice bar. The former was stiffened by a vertical pocket stamped down from the middle of the plate. This joint was applied on a considerable mileage of the Atchison, Topeka & Santa Fe Ry., but the results were not satisfactory, and the further use of the joint was abandoned.

The reason for this is stated to have been that the joints were designed by men who were inexperienced as to the requirements of track material, and that the bars did not fit the rails to which they were applied. In the drawing furnished by

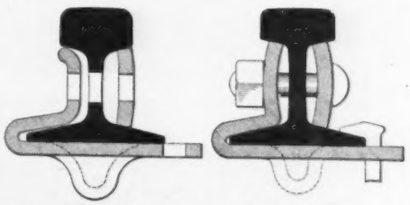


Fig. 1.—Old Heath Rail Joint on 66-lb. Rail; A., T. & S. F. Ry.

Fig. 2.—New "Common-Sense" Rail Joint on 65-lb. Rail.

the railway company, a variation of 1-32-in. from a perfect fit was allowed at both the top and bottom bearing, while these bearings were very narrow. The joints were made according to the drawings, and these conditions are shown in Fig. 1, which represents the joint as made for the 66-lb. rail of the A., T. & S. F. Ry.

This form of joint has recently been re-designed and more carefully manufactured so as to get an exact fit and a wide bearing on both the head and base of the rail. The improved design, as applied to the 65-lb. rail of the so-called Am. Soc. C. E. section, is shown in Fig. 2. The joint is made from boiler plate steel, and forms a bridge support, as well as taking the place of tie-plates on the joint ties, while the plate is made wide enough for spike holes instead of slots; thus acting more surely to prevent creeping. The curved form of the splice bars is claimed to ensure a tight bearing upon the rail and a tight grip of the nut.

The improved form of joint is being introduced by the Common-Sense Rail Joint Co., 304 Tacoma Building, Chicago, Ill., whose factory is at Chicago Heights. For the drawings from which our illustrations are made we are indebted to Mr. W. E. Dorwin, Manager of the company.

THE NEW COAST SURVEY STEAMER "PATHfinder" will be launched at the yard of Lewis Nixon, Elizabethport, N. J., on Dec. 7. This vessel is 196 ft. long over all; 165 ft. long on water line; 33½ ft. beam; about 20 ft. deep, and has a displacement of 875 tons. The average speed will be 12 knots, and the boat is especially designed for work in Alaskan waters.

THE SEA-GOING BATTLESHIP "WISCONSIN," to be launched this week by the Union Iron Works, of San Francisco, was contracted for on Sept. 19, 1896, for $2,674,950, for hull and machinery; the keel was laid on Feb. 9, 1897, and the contract calls for completion on Sept. 19, 1899. She is classed as a sea-going coastline battleship, and her general dimensions are as follows: Length on load water-line, 368 ft.; extreme beam, 72 ft. 2½ ins.; mean draft, 23½ ft.; 11,525 tons displacement, and 6,802 tons gross tonnage. She will have twin-screw vertical triple expansion engines of 10,000 I. HP., and a contract speed of 16 knots. Her side armor is 16½ ins. thick at top, tapering to 9½ ins. at the bottom, and 13¾ ins. thick at the water-line; the two turrets are 17 and 15 ins. thick, and the barbettes 15 and 10 ins. thick. The protective deck is 3 ins. thick forward and 4 ins. aft on the slopes, and 2¾ ins. thick on the flat. She will contain 12,464 cu. ft. of corn-pith obdurating material. The main battery includes four 13-in. guns, in two turrets, and 16 6-in. rapid-fire guns. The secondary battery has 16 6-pdr. and four 1-pdr. rapid-fires, one Colt and two machine guns; there will be four Long-Whitehead torpedo tubes. She will carry 40 officers and 449 men. Above the belt-armor she has 5½ ins. of steel protecting the 6-in. gun positions. She is divided into about 300 water-tight compartments, each of which may be separately pumped out, or ventilated by forcing in air; and she has more than 80 auxiliary engines. Bilge keels are provided. The axis of the forward 13-in. guns is 26½ ft., and the after 13-in., 19 ft. above the water surface; the 6-in. guns are from 15 to 22½ ft. above this surface.

THE SUMATRA OIL WELLS are failing, according to a report made by U. S. Consul Everett, at Batavia. The old wells are giving out more quickly than new ones are bored. This state of affairs is said to be due to the conservatism of the Dutch government, which will not permit foreign capital to develop the oil fields, which are among the richest in the world.

ECONOMY TEST OF A UNIQUE FORM OF FEED PUMP.*

By F. Meriam Wheeler, M. Soc. N. A. & M. E.†

During the past few years considerable attention has been given to the subject of steam economy of the auxiliary machinery on steam vessels, particularly those on warships, where a saving of coal has much to do with the steaming radius of the vessel. Under favorable conditions, as, for instance, in the full power trials of the United States warships, it has been found that in the case of the main feed pumps the average indicated horsepower developed by such pumps is about ½% of the I. HP. on the "Minneapolis" the very best economy shown in the case of the main feed pumps was a little over 93 lbs., while the poorest showing was over 200 lbs. per I. HP. per hour. The particular pump my paper refers to did its work with an expenditure of only 52 lbs. of steam per I. HP. per hour, which, considering the fact that it was quite a small unit, is a most excellent showing.

The test referred to was conducted by experts connected with the engineering department at the works of the well-known engine builders, Messrs. Willans & Robinson, at Rugby, England, and was for the benefit of the British Admiralty.

The feed pump tested consisted of a pair of Blake "Simplex" vertical double-acting steam pumps arranged on the cross-compound plan, with h. p. cylinder 6 ins. diameter, l. p. cylinder 9 ins. diameter, two water cylinders 3½ ins. diameter and all 8-in. stroke. The steam is first used in the 6-in. cylinder, and then expanded into the 9-in. cylinder. I desire to call attention to an important feature of this arrangement of pumps in that it has all the advantages of the duplex system, so far as the continuous flow of the water is concerned, and yet either side can be run as a separate pump in case of accident to the other side. Then again, the economy of compounding is secured with but two steam cylinders instead of four, as would be the case of a compound duplex pump. Therefore, there is less loss of steam from cylinder condensation and clearance is reduced to a minimum, as the valve gear of one pump is not operated by the opposite pump, as in the duplex system; consequently, one side can make a full and complete stroke without interference from the other side of pump.

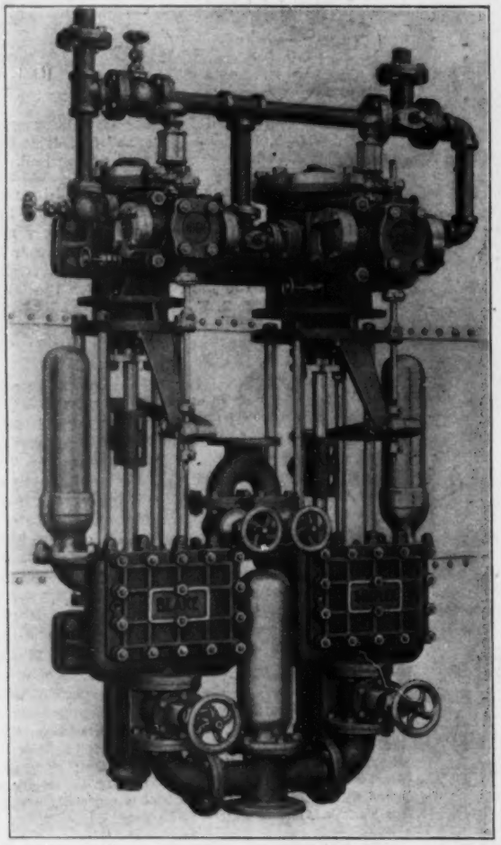


FIG. 2. PERSPECTIVE VIEW OF BLAKE "SIMPLEX" BOILER FEED PUMP.

The Geo. F. Blake Mfg. Co., New York City, Builders.

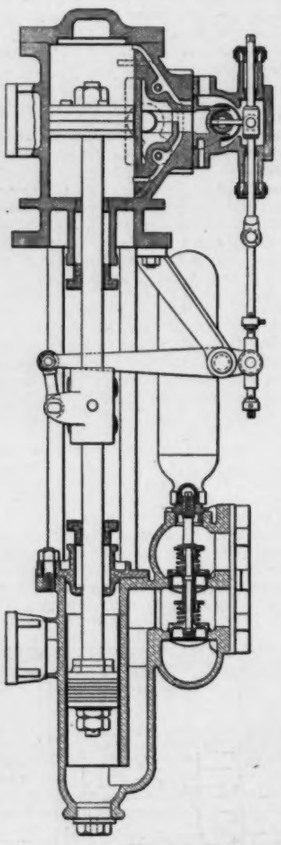


Fig. 2. Vertical Section Through One Side of Blake "Simplex" Boiler Feed Pump, Showing Steam Mechanism.

of the main engines. I mention this fact to show that feed pumps use more power than any other pumps of a vessel. It will therefore be seen that the feed pump is quite an important auxiliary, and everything should be done to improve its economy in the use of steam. For this reason I have given considerable attention to the subject, and take pleasure in now bringing to the notice of the Society the "economy test of a unique form of feed pump" recently conducted in England, in which the economy was quite remarkable compared with that of the ordinary type of steam pumps usually employed for feeding boilers.

It has been shown by tests that the steam consumption of a feed pump of the duplex type (the one most commonly in use in the vessels of the U.S. Navy) will average about 120 lbs. per I. HP. per hour. In the tests made

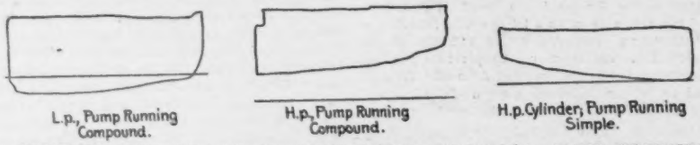


FIG. 3.—INDICATOR DIAGRAMS TAKEN FROM STEAM CYLINDERS; PUMP OPERATING COMPOUND AND SIMPLE.

(h. p. = 120-lb. spring; l. p. = 50-lb. spring.)

Two tests were made: First, by running the pump compound; and, second, by shutting off entirely the low pressure side and running the high pressure side as a simple pump. As mentioned above, the economy of the pumps when running compound was at the rate of 52 lbs. weight of steam per I. HP. per hour, while the economy of the pump running as a simple pump was at the rate of 93.41 lbs. per I. HP. per hour. The following are the particulars:

	Compound.	Simple.
Duration of test, minutes	20.55	18.35
Double strokes per min., each side	40	54
Average length of strokes, ins	8.06	8.05
Initial steam pressure, lbs. per sq. in.	112.5	87.5
Mean steam pressure, lbs. per sq. in. h. p. cyl.	58.06	62.2
" " " " l. p. cyl.	30.28	....
Power developed by h. p. cyl., HP	2.54	3.06
" " l. p. cyl., HP	3.07	....
Total power developed, HP	5.61	....
Total weight of steam used, lbs.	100	175
Weight of steam per hour, lbs.	292	370
Weight of steam per hour per I. HP., lbs.	52.04	93.41

The steam-valve mechanism is very simple, and is shown by the sectional view of the pump herewith. It will be seen that the valve rod (so called) has no valve directly attached to it as is usual; it merely rotates the auxiliary piston, which latter combines within itself the auxiliary valves. This rotating motion is a great advantage, as it frees the auxiliary piston from possibility of sticking for any reason, causing the pump not only to be positive in its action, but securing uniformity of wear. The rolling movement given this auxiliary piston by means of the "valve rod" and the intermediate swinging pin or tongue, opens and closes the auxiliary ports, which, in turn, control the steam to operate the auxiliary piston, moving said piston back and forth across the main steam cylinder. The auxiliary piston, like the main piston, is packed with spring rings.

A plain D slide valve is attached to this auxiliary piston, which valve supplies steam to the main cylinder through the two sets of ports, i. e., the main steam ports and the starting ports. By this cross arrangement of steam chest and valves, the pump can work just as well vertically as horizontally.

As regards the amount of steam that can be saved by this system, there is no doubt but what the pump will save its own weight in coal in 24 hours steaming. With larger size pumps, and with steam pipes covered, the economy of the "Simplex" compound would be even better than that shown in these tests.

Taking the case of a large trans-Atlantic steamer developing 30,000 I. HP., which I understand will be the engine power of the new White Star S. S. "Oceanic," now building, the amount of coal that could be saved on a trip (say, of 5½ days) would be about 77 tons by the use of a system of feed pumps of this cross-compound "Simplex" type, as compared with the simple system of feed pump. This saving in coal not only represents an expenditure of many dollars, but also considerable saving of space which could be made available for cargo or other purposes affording a revenue, thus not only saving money at one end but adding at the other.

*Condensed from a paper read at the annual meeting of the Society of Naval Architects and Marine Engineers.

†93 Liberty St., New York city.

DYNAMOMETER CAR OF THE C., C., C. & ST. L. RY. AND THE UNIVERSITY OF ILLINOIS.

Among the most important tests made to determine the efficiency of locomotives in actual service are those made by means of a dynamometer car, in which is recorded the actual power exerted by the engine in hauling its train, as well as the various conditions under which the engine is working.

The Department of Mechanical Engineering at the University of Illinois has taken up this matter in connection with the practical training of its students, and has recently equipped a new dynamometer car built by the Cleveland, Cincinnati, Chicago & St. Louis Ry., which will be used in the interests of both the engineering students and the railway company. The car, shown in Fig. 1, resembles a freight caboose car. It is 36 ft. long, mounted on passenger car trucks, and is equipped with M. C. B. couplers and the Westinghouse brake. Its weight is about 36,000 lbs.

While the principal equipment of the car is the automatic apparatus for recording the pull on the drawbar of the locomotive, a number of other appliances have been fitted up in order that road tests of locomotives may be made in a safer and more satisfactory way than when all the observationstions are made on the locomotive. With this car attached, only three observers will be required on the engine, namely: two at the indicator and one at the calorimeter in the cab. In addition to this, the placing of the instruments in the dynamometer car avoids the time and trouble of changing them from one engine to another, while tests can be made of any engine by simply fitting it with the indicator and calorimeter and attaching

the car. The instruments can also be more carefully mounted and the readings taken more easily and accurately in this way.

The interior view, Fig. 2, shows the Boyer speed recorder and the Metropolitan recording gage. On the drum of the latter are recorded the strains upon the drawbar. Other instruments are also shown in position. The speed recorder is driven from one of the car axles, in the usual way, and the drum of the recording gage is also driven from the same connection, the clock-work having

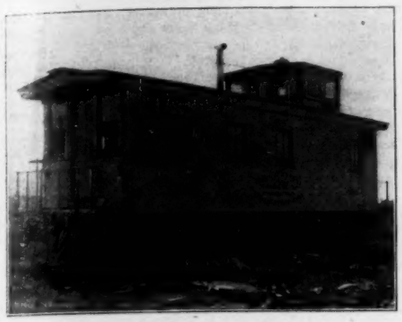


Fig. 1.—Dynamometer Car of the Cleveland, Cincinnati, Chicago & St. Louis Ry. (P. & E. Division), and the University of Illinois.

been removed and suitable reducing gear substituted. Beyond the table, in Fig. 2, against the side of the car, are the 8-in. dynamometer cylinder and its connections, shown in Fig. 3. The piston has cup leather packing, and the piston rod has U-leather packing.

The cylinder is filled with oil in front of the piston, so that the pull on the drawbar is taken by the oil, and the pressure per square inch is recorded by the gage, which is graduated to 1,000 lbs. The drum of the gage is about 5 ins. diameter, and is removed by the recording arm at different speeds, according to the gearing used. The highest speed so far used is 6 ins. per mile. The second hydraulic gage, which is attached to the same pipe, is graduated so as to give a direct reading of the pull in tons upon the drawbar. We are informed that during a recent test the variation of the recording pen was not over 5 lbs. at speeds above 12 miles per hour. At lower speeds, there was more variation, corresponding to the actual conditions, while at the lowest speeds the revolutions of the engine could be counted upon the diagram. A change in the position of the reversing lever or throttle valve makes a noticeable change on the diagram.

When the car is put out of use, the oil in the cylinder is forced back to the elevated storage tank in the corner of the car by admitting air from the auxiliary reservoir of the brake apparatus into the cylinder from above. This is done by the pipes shown in Fig. 3, and any leakage past the piston can be forced into the tank in the same way. When the cylinder is empty, the pull on the drawbar is taken by the draft springs, as usual, the piston then moving nearer the front of the cylinder, but it cannot, under any conditions, strike either end of the cylinder. When the car is to be used for testing, the oil is pumped into the cylinder. The duplex air gage is connected to both train pipe and auxiliary reservoir. In order to prevent any air pressure upon either side of the piston, the two air vent cocks near the globe valves in the air pipes are left open during tests.

While the dynamometer has not yet been calibrated, it is thought that there are but slight losses due to friction. The pointer of the gage moves continually to and fro, slowly and without vibration, and the piston has a continual slight motion, due to variation in the pulling strains and to vibrations of the car. A record is made on the gage even when the dynamometer car alone is being hauled.

The following records are automatically made upon special charts: (1) Boiler pressure; (2) Speed, miles per hour; (3) Pull on the drawbar; (4) Time of passing mile posts. Other records made from observations and readings of the instruments are as follows: (5) Pressure in steam chest; (6) Pounds of water delivered to the boiler; (7) Revolutions of driving wheels per minute; (8) Air pressure in auxiliary reservoir; (9) Air pressure in train pipe. The car will eventually be equipped with electric apparatus, switchboard and signal bells, and arrangements will then be made for recording many other observations on a special chart. These will include the following: (10) Time of taking indicator diagrams; (11) Position of reversing lever; (12) Position of throttle valve; (13) Temperature of escaping gases; (14) Number of weighed bags of coal delivered to the fireman; (15) Direction and velocity of the wind.

The car has been operated on the first division of the Peoria & Eastern Ry. (C., C., C. & St. L. Ry.), between Springfield and Indianapolis, 140 miles, and it is expected that much information of value to the motive power and operating departments will result from the tests. It is soon to be used for making tests with the double-header freight trains between Urbana and Pekin, Ill., 86 miles.

The arranagements for the construction of the car and the conduct of the tests were made by Mr. J. P. Barnard, General Manager of the Peoria & Eastern Division of the Cleveland, Cincinnati, Chicago & St. Louis Ry., and Prof. L. P. Breckenridge, head of the Department of Mechanical Engineering at the University of Illinios. The car was built at the railway company's shops at Urbana, Ill., under the direction of Mr. John McClurg, Division Master Mechanic, and the apparatus was installed under the direction of Asst. Prof. Van Dervoort, of the University.

JOHN WORRALL KEELY.

John W. Keely, whose name has become familiar the world over as the inventor of the so-called Keely Motor, died on Nov. 18 at his home in Philadelphia, after a brief attack of pneumonia. Mr. Keely was over 71 years of age. He was born in Philadelphia (or, according to one account, in Chester, Pa.), Sept. 3, 1827. Little is known concerning his early life, but according to the most reliable accounts, he seems to have drifted from one occupation to another, at one time an upholsterer, at another a druggist's assistant. His first work in the development of the now famous "Mo-

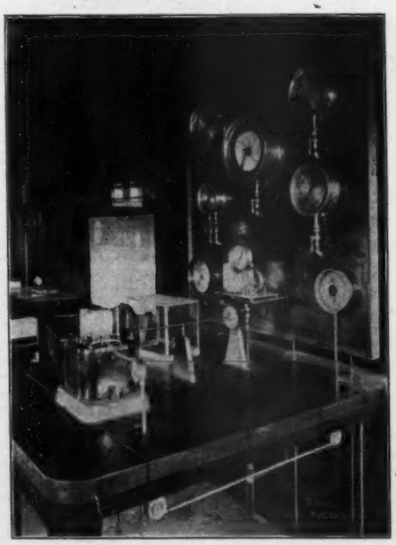


Fig. 2.—Interior of Dynamometer Car Showing Speed Recorder and Gage.

tor," according to his own account, was done while he was the leader of an orchestra, and became interested in the subject of the harmony of sounds and sympathetic vibrations.

His first invention appears to have been made in the early '70's, and we know little more concerning its nature than that it was exhibited in a bathtub. In 1874 he had completed an apparatus which produced a vapor of great expansive force. This vapor was claimed not to be produced by heat, electricity or chemicals. Exhibitions of this apparatus were made, and were so convincing to those who witnessed them that a corporation known as the Keely Motor Co. was organized with a capitalization of $5,000,000. The stock of the company was rapidly disposed of, and has been bought and sold to a greater or less extent on the

Fig. 3.—Dynamometer Cylinder and Connections.

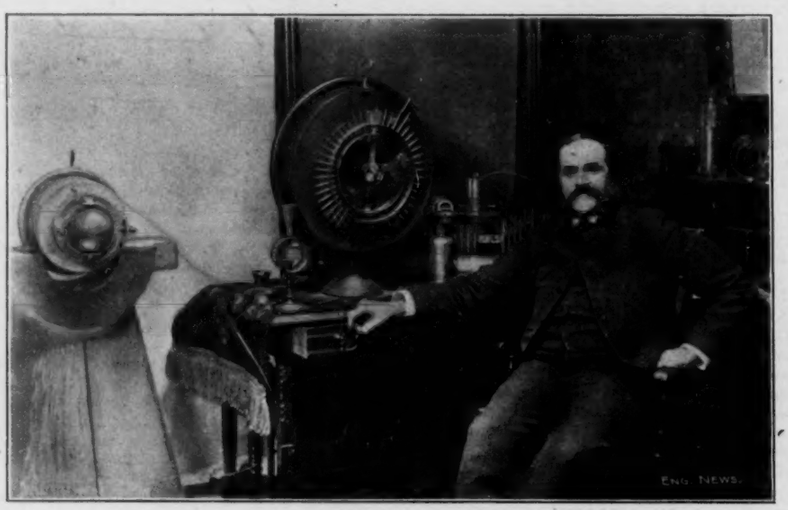
exchanges ever since. The stock was never, so far as we can find, offered for sale to the general public, with the accompaniment of a prospectus in the way that most fake enterprises are floated. The principal holders of the stock were those who had visited Keely's workshop and witnessed his demonstrations, and these were generally eager purchasers. Not a few men sunk the better part of their fortunes in the enterprise. The money paid into the treasury of the company appears to have nearly all been expended for the carrying on of the experiments, and in the building of the various machines which were constructed. Mr. Keely, himself, if one may judge by all appearances, lived in the plainest and most frugal style; and the workshop in which all his experiments and exhibitions were made was shabby and comfortless in all its appointments.

We cannot attempt at this time to describe the work which Mr. Keely did or claimed to do save in the most general way. One misconception concerning it arises from the fact that his invention, if such it may be called, was termed "the Keely Motor." Properly speaking, there is not, and never has been, an actual Keely Motor, meaning by that term a machine adapted to act as a prime mover and develop power for the propulsion of machinery. Certain machines that he has devised have been shown in motion under his hands; but, admitting them to be genuine, they have been nothing more than laboratory exhibits of the crudest order. In fact, the ignis fatuus which Mr. Keely pursued for a quarter of a century, and which he always beheld with unbounded faith only a few weeks or months away, was "a commercial engine." From a personal knowledge of his work extending over a period of nearly ten years, we can say that we have never seen any more than mere possibilities that any of his inventions or discoveries, admitting them to be genuine, would ever possess commercial value, except as discoveries in science. Those who founded the Keely Motor Co., and who stood closest to the inventor all through his quarter century of work, undoubtedly believed otherwise, and Keely himself had the most perfect confidence in his ability alone and unaided to solve every difficulty that stood between him and the long-sought "commercial engine." To those who watched most carefully the various experiments which Mr. Keely performed, however, it seemed clear that if he had, as he claimed, made discoveries of new forces in the ether waves, his knowledge of them was of the vaguest sort, his control over them was uncertain, and their application by him to useful commercial work was in the highest degree improbable.

And now comes the question, were Mr. Keely's experiments and demonstrations genuine? Was

the force which set his apparatus in motion produced from heat, electricity or hidden reservoirs of stored energy, by the methods with which modern physicists and mechanics are familiar, or did it, as he claimed, proceed from some hitherto unknown source? To put the question in another way, could another mechanic, using only known physical methods of generating and transmitting power, duplicate his apparatus and accomplish with it the same results?

In the minds of the general public, this question has long been answered, and the "Keely Motor" has been held to be a gigantic fraud, notable chiefly for its long life. Keely's name will undoubtedly go down to history as that of the greatest pseudo-scientific humbug of the nineteenth century. Whether this verdict is a just or an unjust one, the death of the inventor leaves as an unsolved riddle. It is true on the one hand that Keely never, so far as we know, with one possible exception, submitted all the apparatus by which he performed an experiment to such a thorough examination in detail by competent experts, simultaneously with the experiment, as would remove



John W. Keely

the last possibilities of doubt as to its absolute genuineness and the entire absence of fraud. It is true, on the other hand, that those who witnessed his experiments, and who were competent to judge of them, were almost invariably completely nonplussed and unable to explain the things they saw according to ordinary physical laws. If Mr. Keely performed his experiments by fraudulent means, he was certainly one of the most clever and ingenious mechanics and electricians who ever lived. If he was a genuine discoverer, he lost the fame that might have been his by his eccentric insistence on secrecy, and refusal to submit to investigation. We can, perhaps, sum up the whole matter by saying that Keely's experiments and methods generally had most of the earmarks of a fraud; but it confounded the ablest men who examined his work to tell how it could possibly be accomplished by fraudulent means.

At some other time we may give our readers in more detail an account of the investigations which have been made by members of the staff of this journal, in endeavoring to solve the mystery of Keely's work. The above, however, summarizes the only conclusions that have been reached.

The accompanying portrait of Mr. Keely, sitting in his workshop, with his peculiar apparatus grouped about him, is reproduced from a photograph taken in 1889, for which we are indebted to the courtesy of Chas. B. Collier, Esq., of Philadelphia, who has been for a quarter of a century Mr. Keely's attorney and intimate associate.

AN ACHIEVEMENT IN CASTING TEST BARS is described by Mr. Thomas D. West in a paper to be read before the Pittsburg Foundrymen's Association on Nov. 28. Mr. West is a member of a committee of the association which is making a most extensive research into the qualities of cast iron. It has prepared patterns for casting 200 test bars of different sizes and shapes, ranging from ½ in. to 4 ins., square and round, half to be made in dry sand and half in green sand. The patterns are to be sent to eleven different foundries, working on different grades of iron. It is most essential that the 200 bars of each cast be made under identical conditions as to quality of iron and temperature of pouring, and these conditions have been secured by the method Mr. West describes in detail in his paper. The molds are all set so as to cast the bars on end, and placed near together in a pit 18 ft. long, 8 ft. wide and 2 ft. 8 ins. deep. Parallel to the main runner on one of the longer sides of the bed, and separated from it by an iron plate placed edgewise, there is a basin, 15 ft. long by 12 ins. deep, made to hold three tons of melted iron. This basin is first filled with metal from the ladle, and then the iron plate is lifted 2½ ins., so as to allow only clean metal to flow into the runner. The success of the arrangement was complete. From the time the inlet plate was lifted until the 200 bars, weighing 3,780 lbs., were all poured, scarcely 20 seconds elapsed, and no bars were lost. This first set of bars was cast at the foundry of the Westinghouse Electric & Mfg. Co., at Wilmerding, Pa.

THE ARCHITECTURAL PLANS for the University of California, under the Phebe Hearst donation, were submitted to an international commission, made up as follows: For France, J. L. Pascal; for Germany, Paul Wallot; for England, R. Norman Shaw; for the United States, Walter Cook; for the University of California, J. B. Reinstein. This commission closed its examination of plans at Antwerp on Oct. 4, and it unanimously admitted to final competition the plans of the following architects and firms: Messrs. Barbaud & E. Bauhain, E. Benard, Paris; Prof. F. Bluntschli, Zurich; D. Despradelles & Stephen Codman, Boston; R. Dick, Vienna; J. H. Freedlander, New York; G Heraud & W. C. Eickmuller, Paris; Howard & Cauldwell, Howells, Stokes & Hornbostel, Lord, Hewlett & Hull, Whitney Warren, all of New York. In addition the commission recommended that the plans of the following architects be purchased for the University: Joanny Bernard & Robert, and Charles des Anges, of Paris; Ernest Flagg, of New York, and Skjold Neckelmann, of Stuttgart. The final meeting will be held in California in June, 1899, and the commission will there select the final plans.

THE NEW WATER TUNNEL AT CHICAGO is again to be the source of litigation between the city and the contractors. The controversy is over the work on Section No. 3 of the land tunnel, the contractors for which are Weir, McKechney & Co. The original contract price of 1895 was $350,080, but up to date the city has paid $592,789, and the work is not yet finished. When Mr. Joseph Downey was Commissioner of Public Works he refused to continue payments for masonry filling in large excavations outside the tunnel section. The contractors took the matter into court, but the Supreme Court decided that they were not entitled to any compensation for excavation or backfilling outside of the tunnel proper. The contractors had, however, been misled to some extent by the profiles and borings furnished by the city, and the court decided that an extra sum must be paid where the excavation was partly in rock and partly in earth. The contract price was $2 per cu. yd. for rock excavation, but after the above court decision an agreement was made for $6 per cu. yd. where both rock and earth were encountered, with $10 per cu. yd. for masonry backfilling. This was approved by the city council, and on this basis the contractors are now endeavoring to claim "extras," while the city claims that much of the work was done purposely with a view to such extras. It is charged that after the proper section had been excavated, inclined drill holes were driven so as to bring down great masses of material above the roof, and to include both rock and earth in the excavation. Affidavits to this effect have been made by the city engineer and his assistants on the work, and by consulting engineers, who have been called in. The city engineer also charges that the directions issued by him and his assistants have been wilfully disregarded by the contractors, and that they have left the work in bad condition, without masonry lining, thus endangering the work and the buildings over the line of the tunnel. After paying several bills the Commissioner of Public Works, Mr. L. E. McGann refused to make any more payments, and on Nov. 10 ordered the work stopped. The contractors at once took the matter to the courts, where it is now being tried.

RIVER GAGINGS IN OHIO are under consideration by the U. S. Geological Survey, and Mr. F. H. Newell, Chief of the Hydrographic Division, has recently visited Columbus to see about the work. Within the past year or so the State Board of Health has made a few gagings on three streams in Ohio.

MUNICIPAL OWNERSHIP of water-works at Topeka, Kan., was decided upon at a special election on Nov. 12. The question was on authorizing the city council to issue bonds to buy or build works. The total vote was light, but the majority in favor of municipal ownership was decided, the vote being 1,703 for and 616 against. Within a few days prior to this action at Topeka, popular votes in favor of municipal ownership were cast at Alliance, O.; Meadville, Pa., and Barrie, Ont. The latter place is also about to establish a municipal electric lighting plant. It is reported that on Nov. 12, the authorities of Pasadena, Cal., and representatives of two water companies which now supply the city agreed on a plan for the purchase of the water-works by the city.

A NEW WATER-WORKS PLANT FOR DENVER has been reported on by Mr. J. B. Hunter, City Engineer. The estimated cost of a large storage reservoir, settling basins, filter beds, supply main and distribution system is $5,700,000. The value of the present plant of the Denver Union Water Co. is estimated by Mr. Hunter at $3,764,000, on the basis of the present cost of duplication, and without allowing for the franchise. The company has offered to sell its property to the city for $9,000,000. The mayor has recommended that steps be taken to provide for an election to vote on $6,000,000 of bonds for buying or building works.

A NEW CROP OF WATER-FILTRATION ORDINANCES is springing up at Philadelphia, three bills having been introduced in the select council the other day. Several more ordinances are promised for Dec. 8. Two of the ordinances provide for contracting for specific systems, and one calls for bids under plans to be furnished by the city.

THE NUMBER OF BACTERIA in London crude sewage is 3,899,000 per cu. cm., at the Barking outfall, and 3,527,000 at the Crossness outfalls, according to the average of a number of recent counts by Dr. A. C. Houston, made early this year, under the direction of Dr. Frank Clowes, Chemist of the London County Council. The range at Barking was from 7,260,000 on May 3, to 513,000 on April 15; and at Crossness, from 5,290,000 on March 2, to 2,410,000 on April 20.

THE ELECTROLYTIC MARINE SALTS CO. dies hard. A committee appointed in August to investigate its affairs has made a report against a receivership, but recommending that a committee of citizens take the company's business in hand, with power to test the Jernegan process for getting gold from sea water, and to disentangle the legal snarl into which affairs have drifted.

A NEW METAL TRACK SIGN now being used to some extent on the Pennsylvania lines, the Missouri Pacific and the Wabash R. R., consists of an angle iron post, set in a section of 8-in. sewer pipe, to which it is secured by braces and a collar on the pipe. The pipe is buried in the ground and filled with concrete or earth well tamped, the bell of the pipe giving a good area for the foundation, so that the post will remain vertical. Sheet iron targets of any desired form or size are riveted to the iron post. These signs are manufactured by the Mathews Woven Wire Fence Co., of Jacksonville, Ill.